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MULTI-COMMUNITY COMMAND AND CONTROL SYSTEMS IN LAW ENFORCEMENT

–an introductory planning guide

R.L. Sohn
E.A. Garcia
R.D. Kennedy

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Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California 91103

March 31, 1976

Prepared for

National Criminal Justice Information and Statistics Service
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PREFACE

This document presents results of work supported by the Law Enforcement Assistance Administration, U S. Department of Justice, under the Omnibus Crime Control and Safe Streets Act of 1968, as amended. It was sponsored under an inter-agency agreement with the National Aeronautics and Space Administration through Contract NAS 7-100 Points of view or opinions stated in this document are those of the authors and do not necessarily represent the official position of the U.S. Department of Justice

FOREWORD

Cooperative systems are valuable because they bring advanced technologies such as computer-aided dispatch and digital communications to the smaller cities who individually could not afford them, and because significant savings in operational costs can be realized through the shared services and facilities.

This book has been prepared and distributed to provide public safety planning personnel with a compact source of information on one of the most important aspects of police command and control automation, namely multi-community command and control systems.

This volume is one of a series prepared under the sponsorship of the Law Enforcement Assistance Administration (LEAA) to provide planning guidelines on the various aspects of police command and control automation. The complete series consists of the following documents:

Title	Document No.
Application of Mobile Digital Communications in Law Enforcement	JPL SP43-6 Rev. 1
Application of Computer-Aided Dispatch in Law Enforcement	JPL 5040-16
Application of Automatic Vehicle Location in Law Enforcement	JPL 5040-17
Patrol Force Allocation in Law Enforcement	JPL 5040-18
Multi-Community Command and Control Systems in Law Enforcement	JPL 5040-19

The series was prepared by the Jet Propulsion Laboratory of the California Institute of Technology, using the results of studies sponsored by LEAA at JPL as well as at other institutions. The documents are being distributed as part of LEAA's mission of giving technical assistance to state and local law enforcement agencies. They are addressed to the local law enforcement planner who must face practical working problems in deciding what degree and kind of automation best suits his department. Our intention has been to give him the basic understanding he needs to make such a decision, and procedures for making the associated analyses or having them made. The manuals are developed within the framework of the overall command and control system so that potential benefits of individual innovations can be evaluated in terms of improved system performance.

The technologies that are available to law enforcement agencies today have the promise of making their operations more efficient as well as more effective. Our hope is that this series of documents will provide a clear and concise picture of what that promise is and what is involved in making it a reality.

S. S. Ashton, Jr.
Systems Development Division
National Criminal Justice
Information and Statistics Service
Law Enforcement Assistance Administration
United States Department of Justice

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ABSTRACT

A set of planning guidelines for multi-community command and control systems in law enforcement is presented. Essential characteristics and applications of these systems are outlined. Requirements analysis, system concept design, implementation planning, and performance and cost modeling are described and demonstrated with numerous examples. Program management techniques and joint powers agreements for multi-community programs are discussed in detail. A description of a typical multi-community computer-aided dispatch system is appended.

This document is one of a series of five guideline manuals on mobile digital communications, computer-aided dispatch, automatic vehicle location, patrol force allocation, and multi-community command and control systems for law enforcement applications.

1. INTRODUCTION

Several recent technical developments have made possible significant advances in police command and control operations (and those of other emergency services). The rapid advances in solid-state electronics, especially integrated circuits and associated digital devices, have led to general availability of powerful computers at drastically reduced prices and to the whole spectrum of digital communications.

This series of documents has been issued to summarize the current state of such developments as they apply to police command and control and to assist police department planners in determining how best to apply these new technologies to their own needs This document is the fifth in the series, the complete series consists of the following:

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Application of Mobile Digital Communications in Law Enforcement	JPL SP43-6 Rev. 1
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The preceding documents have considered particular aspects of new technology applied to police command and control The purpose of this document is to discuss these techniques as an interrelated set making up a new type of police command and control system The advent of the 911 emergency number in all jurisdictions over the next few years will create a requirement for certain new procedures and techniques, and constitute a natural base for planning a completely new and advanced system.

Although computer-based systems are much less costly than a few years ago, they are still beyond the reach of most small police departments. A solution, to this problem has been found by a few departments that are part of a cluster of contiguous jurisdictions on the outskirts of a large city. Three Chicago suburbs (Oak Park, Forest Park, and River Forest) have combined to set up a computer-aided dispatch facility that services all three departments without in any way limiting their independence. A similar system is being implemented for seven contiguous cities in the Los Angeles area (El Segundo, Manhattan Beach, Hermosa Beach, Redondo Beach, Palos Verdes Estates, Gardena, and Hawthorne). This document is addressed particularly to planners in departments whose size and location make it possible to consider similar arrangements with neighboring jurisdictions. The details of existing multi-jurisdictional systems are described to give a clear idea of what such a system looks like and how it operates. Present indications are that it can effect significant savings in operating costs for all the participants.

The term police command and control is used in these documents in order to bring out the fact that police operations are of essentially the same nature as other command and control operations such as the military, public utilities, transit systems, and other systems with rapidly changing demands that require frequent decisions about the allocation of resources. The elements of any command and control system are

- Determining the need (e.g , calls for service)
- Determining the status of the resources (patrol unit status)
- Deciding what resources are to be applied (dispatch decisions)
- Issuing the necessary command (dispatches)
- Monitoring and supporting the operation (communications with patrol unit)

It is important to note that command and control is not synonymous with communications. A command and control system includes, in addition to the communication links, the data bases where incident and patrol unit status data are stored, the procedures for handling and storing the data, the procedures for arriving at field unit dispatch decisions, the displays used to present data to decision makers, and the personnel and procedures for exercising general control of the operation. In automated systems, a computer and its related equipment are essential parts of the command and control system

The previous documents in this series have indicated in each case the need for a requirements analysis as a basis for planning implementation of a new technology Such an analysis is even more necessary when an integrated automated command and control system is being planned, especially if it is to be a multi-community or multi-jurisdictional system. The system must be analyzed as a whole, taking into account the interactions of all the elements In general, the elements of a complete automated police command and control system would be the following

- A computer-aided dispatch system.
- Digital communications with patrol units, including mobile digital terminals in the patrol units (and, possibly, digital portable radios).
- The interface with remote data bases (DMV, NCIC)
- The interface with the 911 emergency number system.
- Automatic number indication and automatic location indication of the calling telephone (planned as part of the 911 system).
- Computer programs to aid in the daily or longer-term allocation of patrol forces and in the analysis of crime or incident patterns for law enforcement management purposes

This list does not include the radio communication links that are assumed to be available, although reallocation of the channels may be necessary Automated equipment can help in the management of channel capacity, however, for example, by dynamic channel allocation techniques

Many advantages are offered by cooperative, multi-community or multi-jurisdictional command and control system implementations·

- Significant savings can be made in operating costs, most particularly in personnel costs
- Savings in procurement of both capital equipment and implementation costs because one system is being designed and put into operation, not one for each separate jurisdiction
- Radio channel crowding is especially troublesome in the case of several adjacent but separate radio dispatch systems A combined computer-aided system helps relieve this congestion in two ways
  - (1) All the channels of the departments can be managed as a common resource, resulting in efficient allocation of this resource, and
  - (2) Converting a portion of the message traffic to digital form reduces channel congestion for the same volume of messages.
- Federal funds to subsidize upgrading of local police command and control systems are usually easier to obtain for such joint or cooperative systems. It may be difficult for a small department to obtain such funds as an individual applicant.

Service to the public can be improved in a number of ways.

Improved Dispatching. With promptly updated status always immediately visible, instant access to all required files in the computer, and automatic input of all routine data (time, data, ID's etc) by the computer, the dispatcher can process dispatches faster and more accurately.

Use of Resources. With the status of all forces of the cooperating communities on view at a central location, these forces can be allocated in a more efficient manner and can be mobilized to handle cross-jurisdictional incidents more effectively.

Response to Calls. With an Automatic Call Distribution System to allocate incoming calls to the next available operator, calls can be served in the sequence of their arrival and answered more rapidly because the telephone answering resources have been pooled.

Call Processing. Taking of incident data by the telephone clerks is made faster and easier by the keyboard/CRT procedure Routine data is handled by the computer, and information given is checked for validity (especially addresses) With the automatic number/location identifier feature of the 911 system implemented, location and telephone number can be entered automatically The address verification function of the computer will also automatically indicate which police department has jurisdiction over the location of the incident.

Reduced Response Time. Because of the faster operation at both the telephone answering and dispatcher positions, and the more accurate information available to both, overall response time may be reduced.

Dispatcher Efficiency. The efficiency of the dispatcher is not only improved by the automated functions, but by a quieter working environment and reduced stress during peak load periods

Officer Safety The safety of field is enhanced by several features of the automated system information on suspicious vehicles and persons is provided to field officers in seconds, access to radio channels by field units is less subject to delay, digital communications are less subject to being overheard.

Interagency and Interjurisdictional Communications. This traditional and recurring problem is significantly reduced by proper allocation of communications channels between agencies (police, fire and emergency medical services) and between communities.

Management. Management functions are aided by automated record keeping and report generation. Reports by field personnel can be reduced in number and preparation time.

All these technologies are of current interest in the law enforcement community, and all of them are being developed and encouraged by the Law Enforcement Assistance Administration (LEAA). Digital communications and computer-aided dispatch are the most widely adopted of these technologies, although still only a small percentage of police departments have implemented such systems. Through the kind of cooperative, multi-community or multi-jurisdictional automated command and control systems described in this document, it will be possible for smaller departments to enjoy the benefits of the new technologies. Establishing a joint powers or similar agreement to implement and operate a cooperative command and control system is perhaps the most difficult obstacle to overcome.

Section 2 of this manual outlines some system concepts for automated command and control systems, in particular those for multi-agency (police, fire, emergency medical services) dispatching and multi-community or multi-jurisdictional dispatching through cooperative command and control facilities

Section 3 outlines briefly the planning process for a new automated command and control system. Elements of joint powers agreements and program management organization are discussed in Section 4. Section 5 then discusses the first step in this planning process, the analysis of requirements

Subsequent sections deal with design concepts, implementation schedules and costs and cost-benefits analysis

Appendix A contains a description of an operational multi-community computer-aided dispatch system

2. SYSTEM CONCEPTS

An automated police command and control system performs the same functions as one that is not automated, the differences are mainly in the efficiency with which the operations are performed and the added resources that can be made available (especially fast access to local and remote data bases). Automation also provides a degree of flexibility not usually attainable with manual systems This section defines some of the system-level concepts the planner should consider in connection with the basic decisions that must be made for an automated command and control system.

2.1 Basic Concept

The different elements of an integrated automated command and control system for law enforcement are described in detail in the other documents in this series. The core of such an integrated system is the computer-aided dispatch (CAD) system, and the next most essential element is a system of digital communications with patrol units. An automatic vehicle location (AVL) system is a useful addition, but probably has less effect on overall operations per dollar invested than the two elements previously mentioned Patrol force allocation techniques are related to command and control functions, and can be applied when a suitable computer is already available (for use in a CAD system, for example)

Figure 1 summarizes the concept of an automated police command and control system Two points are evident from a review of the figure

- All transactions in the system except incoming calls to the telephone clerk or complaint board operator (CBO) and the voice messages between dispatcher and patrol units are in digital form

- The CAD computer is at the heart of the system, supporting every aspect of the operation

Putting as much as possible of the information to be handled into digital form makes it possible to take full advantage of the remarkable speed and capacity of present-day computers. It also serves to reduce the volume of message traffic on the usually crowded radio channels; this is an important benefit in many cases. In general, all of the operations listed that are performed by the computer are carried out so fast that the person concerned (CBO, dispatcher, patrol unit officer) is not aware of any delay at all.

The benefits to be expected from an automated police command and control system are in many cases difficult to measure in numerical terms, and those that can be measured do not show dramatic changes. Nevertheless, there are important improvements associated with automation·

- Stress on personnel may be reduced under heavy load conditions, this enables the personnel to make better decisions.

- Response time is reduced, primarily by reducing the time between receipt of a call for service and assignment of a patrol unit to the incident It is still necessary for the patrol unit to reach the scene of the incident, and automation has a relatively small effect on the average travel time

- Officer safety is enhanced because more information is made immediately available to the officer, and patrol unit status (including emergency messages), is transmitted quickly and in encoded form.

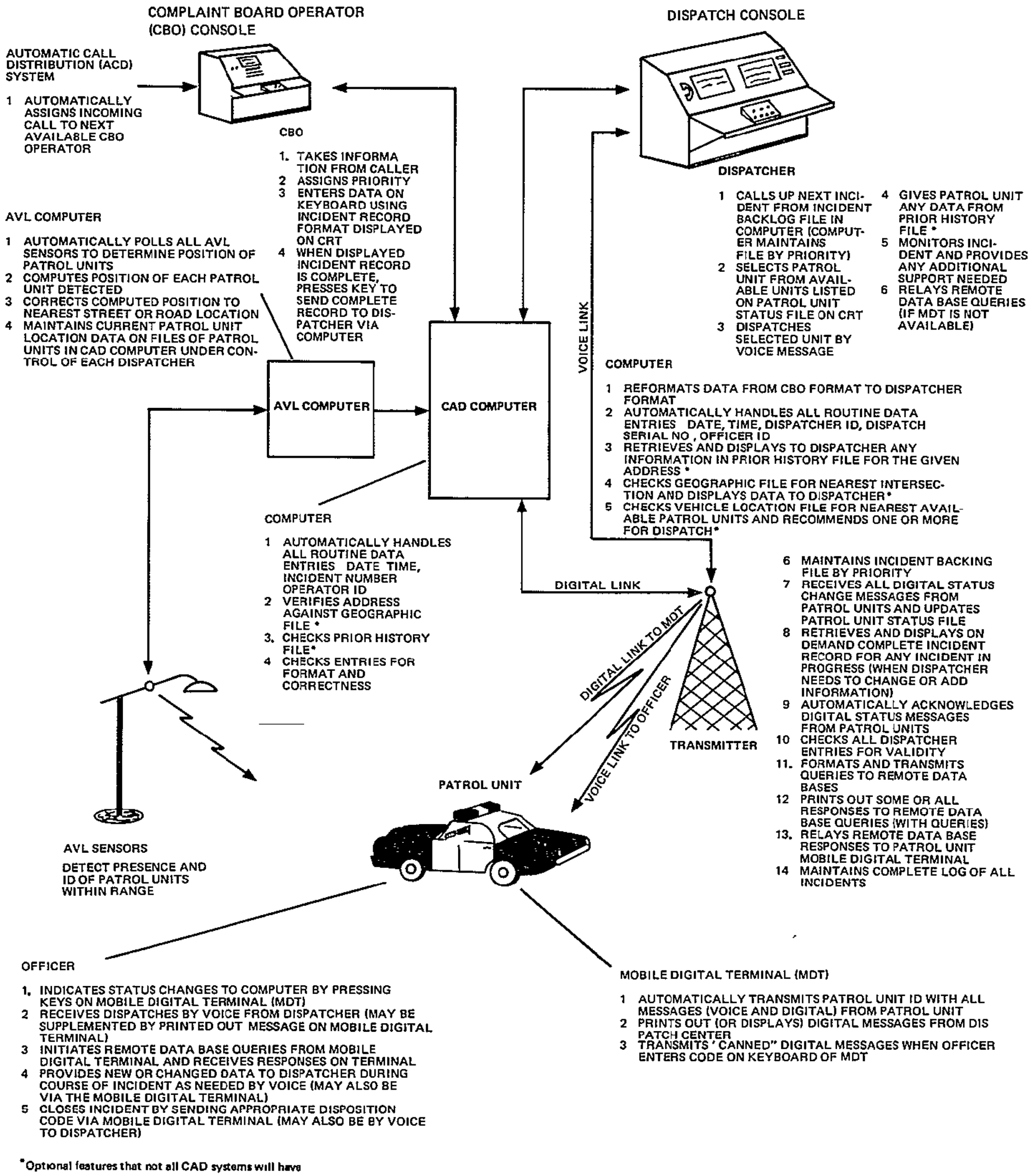
- Status and other digital messages are in a form that cannot be overheard by the general public without special receiver equipment.

- Both CBO and dispatcher efficiency may be improved to the extent that in a large department it is possible to eliminate one or more positions, or allocate existing positions to special functions, such as one operator for data base queries, and a second for ambulance and tow services, etc., this decentralization of functions significantly reduces the stress on the dispatch stations, which are the most heavily loaded positions. In small departments (not more than three or four dispatchers) it is unlikely that any positions can be eliminated.

- Overall operations can be improved because of the large increase in the amount and variety of management information that becomes available with the automated system, the production of management and statistical reports also becomes much faster and less expensive.

2.2 Operating Modes

A command and control system for law enforcement needs to have provisions for modes of operation under all foreseeable conditions Planning for an automated system



*Optional features that not all CAD systems will have

Fig. 1 System concept of integrated automated police command and control system

should include provisions for the various operating modes that might be required. In general, these are.

Normal Operations. This operating mode covers the routine monitoring of calls for service and responding to them Such operations are required around the clock and every day in the year.

Backup Operations. Although the reliability of modern automated equipment is very high, provision must be made for operating in the event that there is some type of failure that interferes with automated operation. This is usually a manual system, although there may be modes where that part of the automated equipment that has not failed can continue to be used. Plans are needed for smooth transfer from normal automated operations to backup manual operations and back to automated operations

Emergency Conditions The command and control system should be able to respond to emergency conditions in the community. This response takes the form of special real-time coordination of resources from a command center In minor emergencies the command center may be in the dispatch center, with a designated Tactical Officer having authority over all the communication links needed to coordinate the response to the emergency. Major emergencies are typically coordinated from the scene in some type of mobile command unit with adequate communications equipment to coordinate the response. Such a mobile command unit may be a station wagon or van, or for major disturbances it may consist of several trailer vans with autonomous power supply and communications equipment with access to the systems data processing.

The equipment and procedures planning should provide the necessary equipment, interfaces, and procedures so that an emergency command post can be set up quickly and smoothly.

Unusual Occurrences. This term designates a condition requiring dedicated and extended coverage of an area affected by a major disturbance or disaster Command and control typically requires on-the-scene coordination of many police and other emergency units, specialized equipment, field intelligence gathering, logistic support, and liaison with other agencies operating at the scene. One or more command posts of the type described for emergency conditions may be established. Plans for this and other emergency conditions should include not only equipment and procedures, but whatever special files and software might be required to operate under the specified conditions.

2.3 Community Integrated Public Safety Systems

Large cities normally have essentially independent police, fire, and emergency medical service departments, each with its own command and control system and communications. For medium sized or smaller cities it is often practical as well as economical to combine the command and control operations in a single public safety dispatching system that assures response to an emergency with the appropriate personnel and equipment at any time of day, every day in the year

With the advent of the 911 emergency calling number, there will necessarily be a single point where calls are received, even though the dispatching operations are completely separated. In smaller cities these operations can be combined to some extent, thereby effecting important savings in operating costs and equipment. Figure 2 shows the system elements for an integrated system. Some significant economies can be effected by sharing the relatively expensive computer-aided dispatching facilities where similar data processing functions are required by all emergency services The most obvious of these functions is the computer-stored street index or geographic file of all addresses with the nearest intersection for each Response times for all services can be improved by real-time access to this file, and when the Automatic Number Indication/Automatic Location Identification (ANI/ALI) service becomes available from the telephone company the entire process of indicating the address on the dispatch data and identifying the nearest intersection can be automated Table 1 lists the components of a combined system, indicating which can be shared.

2.4 Decentralized Dispatching with Central Computer Facilities

The possibility of combining police command and control operations to the extent of a single computer center for several adjoining communities has been mentioned previously The only such cooperative system presently in operation is that in the Chicago area, Figure 3 illustrates the concept. The Chicago-area system is called AIDS for Automatic Interactive Dispatch System The three cooperating cities, Oak Park, River Forest and Forest Park, have a combined population of about 100,000. The computer facility is located in one of the departments (Oak Park), with the required communication links to enable the other two departments (River Forest and Forest Park) to utilize the central computer facilities and the central radio transmitting facilities.

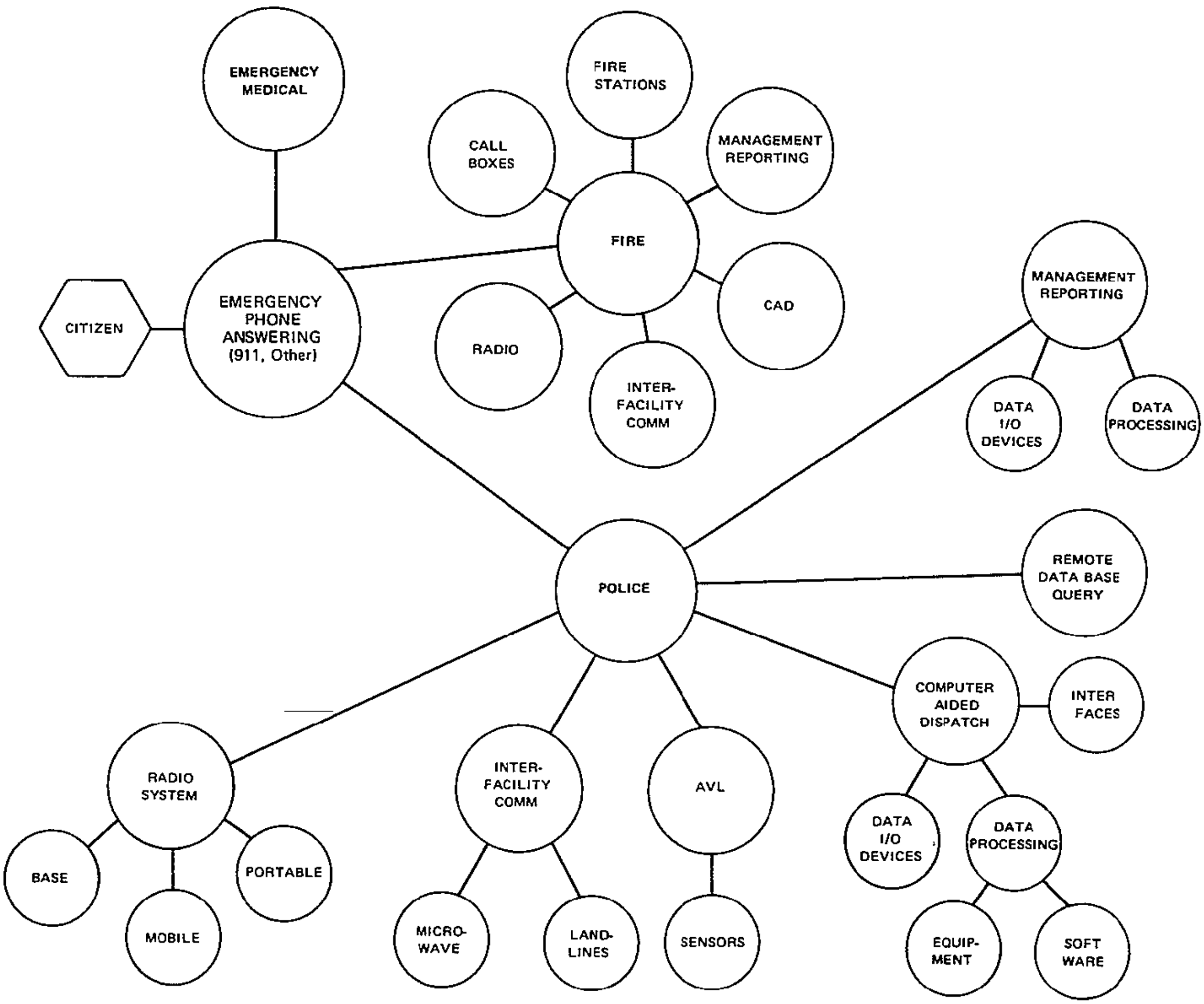


Fig 2. Integrated public safety system

Table 1. Command Control Functions

		Dedicated			
		Police	Fire	EMS	Shared
1.	Emergency Phone Answering Capability (911)				X
2	Tie-Lines — Centrex				X
3	Dispatch Center Building and Power				X
4.	Base Station Radio Transmitter/Receiver Site(s) and Building(s)				X
5	Radio Antenna Towers				X
6	Antennas, Transmitters, Receiver, Frequencies	X	X	X	Special
7.	Automatic Vehicle Monitoring				X
8	Microwave Link (Towers) from Dispatch Center to Base Station				X
9	Microwave Channels	X	X	X	
10.	Computer and Peripherals (CAD, AVM, MDT)				X
11.	Software, Geo-File	X	X	X	Partial
12.	Complaint-Taking Console Positions	X	X	X	Partial
13	Radio Dispatch Console Positions	X	X	X	Partial
14	Mobile Data Terminals	X	X	X	Base Computer
15	Portable Data Terminals	X	X	X	Base Computer
16.	Supervisory Console Positions	X	X	X	Partial
17.	Map Display	X	X	X	Partial
18	Call Boxes, Alarm Boxes, Alarm Systems	X	X	X	
19.	Radio System Maintenance				X
20	Digital System Maintenance				X
21.	Microwave System Maintenance				X
22	Building Maintenance				X
23	Management Reporting	X	X	X	Partial

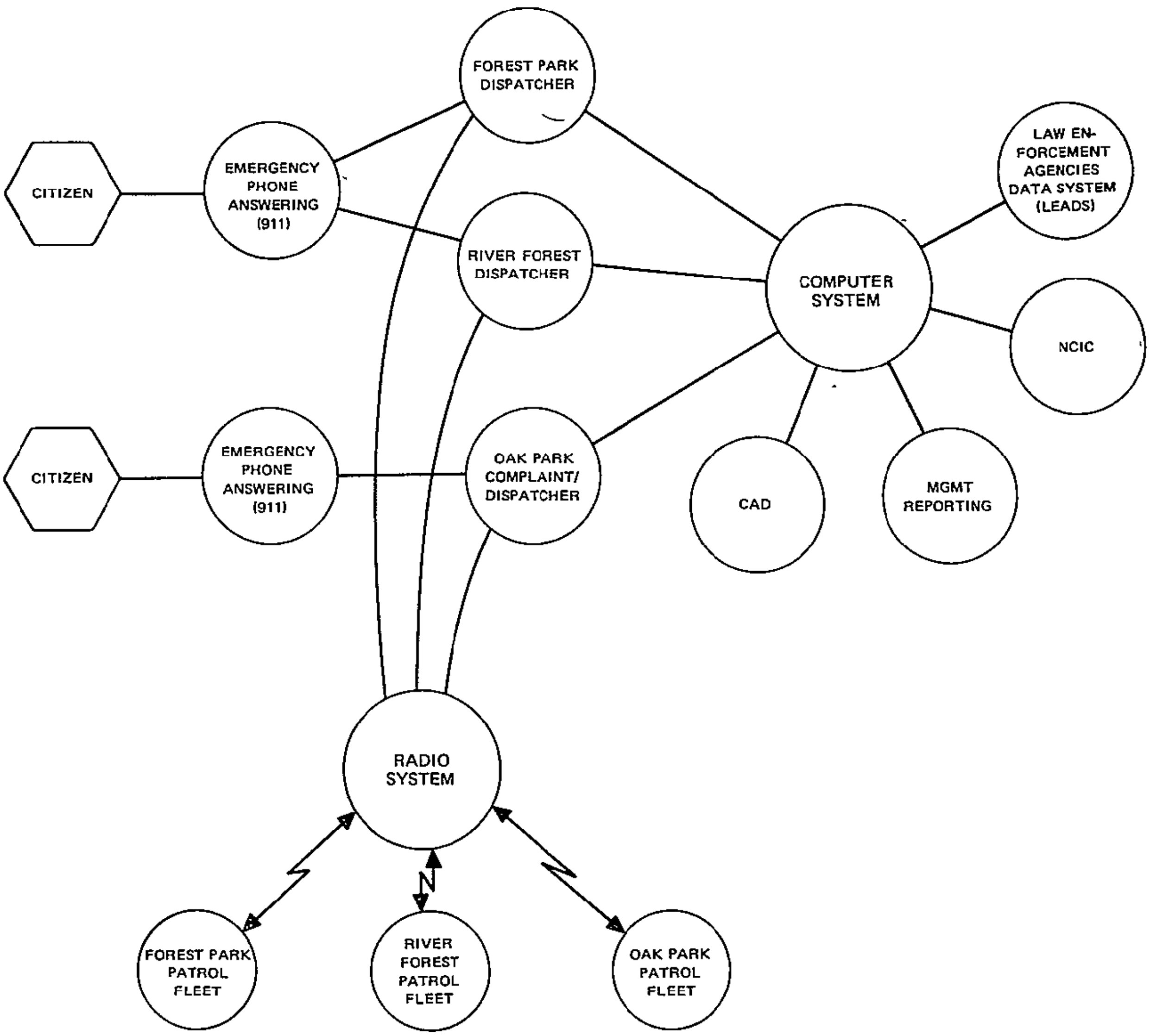


Fig 3. Decentralized dispatching with central computer facilities

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2.5 Decentralized Dispatching with Central Radio Facilities

Another system concept is illustrated in Figure 4. This concept is used by the Los Angeles County Sheriff's Department. Individual stations accept calls for service from their local areas and maintain their files and control their own patrol units. The radio facilities for communicating with all field units are in a single location, however This not only reduces the cost of radio facilities, but makes the management of channel utilization more efficient.

2.6 Fully Centralized Multi-Community Command and Control

The systems described in the preceding sections delineate partially centralized command and control systems in which one element such as the radio or computer facility is shared by a number of communities. A fully centralized multi-community command and control system is in the process of being established by a consortium of cities in the Los Angeles–South Bay area. In this application central dispatching and radio facilities will serve all cities in the consortium, which has a combined population of about 275,000. The system includes the 911 emergency number service, and command and control facilities for the fire departments and emergency medical services. Figure 5 illustrates the concept.

The administrative procedure for the South Bay cooperative system is a new legal entity created by the cooperating communities to provide the specified services to each and controlled jointly in accordance with specified procedures A Joint Powers Agreement executed by the cooperating communities will serve as a legal basis for the cooperative automated command and control system.

It is essential in a fully centralized multi-community system of this type that each community retain full control over its field units, the units can be dispatched from a central facility, but each city must maintain a facility within its jurisdiction to monitor all dispatch operations of the central facility affecting its field units, with a capability of overriding a dispatch, or taking control of its fleet if the situation warrants.

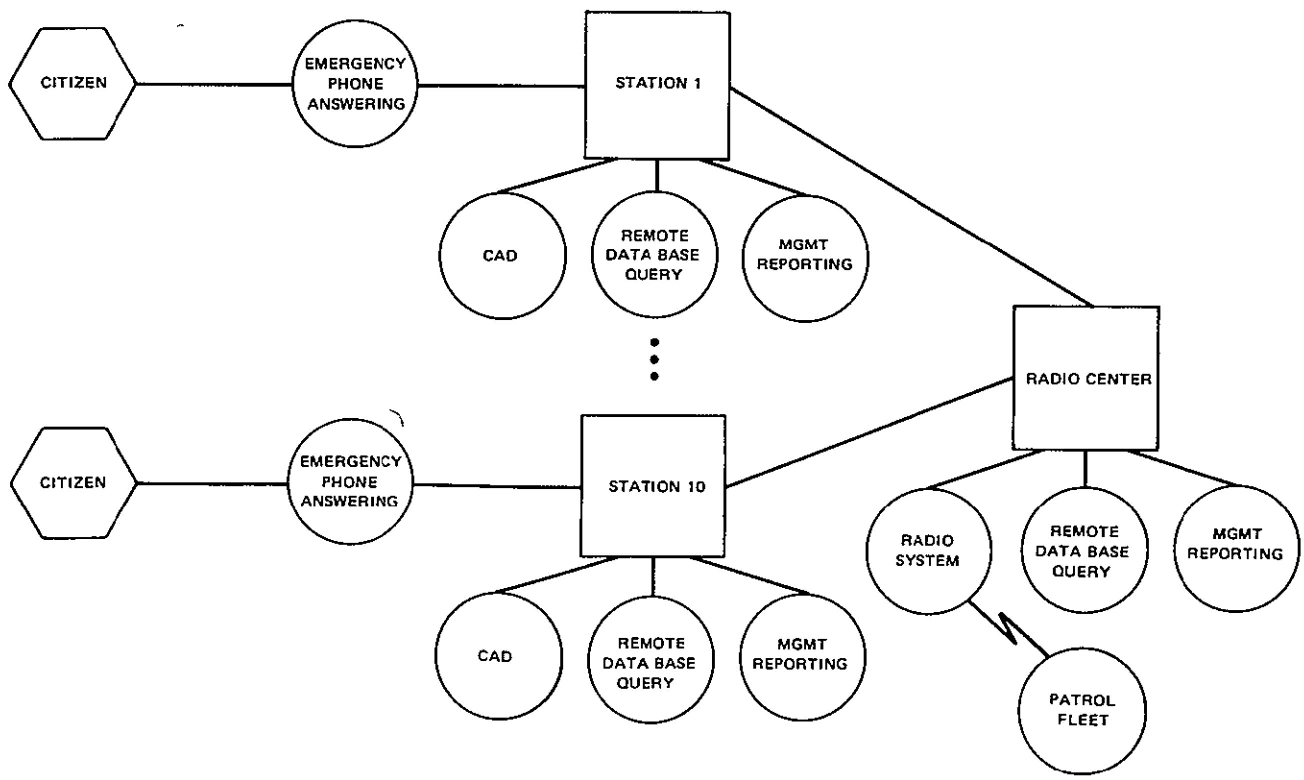


Fig 4. Decentralized dispatching with central radio facility (Los Angeles County Sheriff's Department)

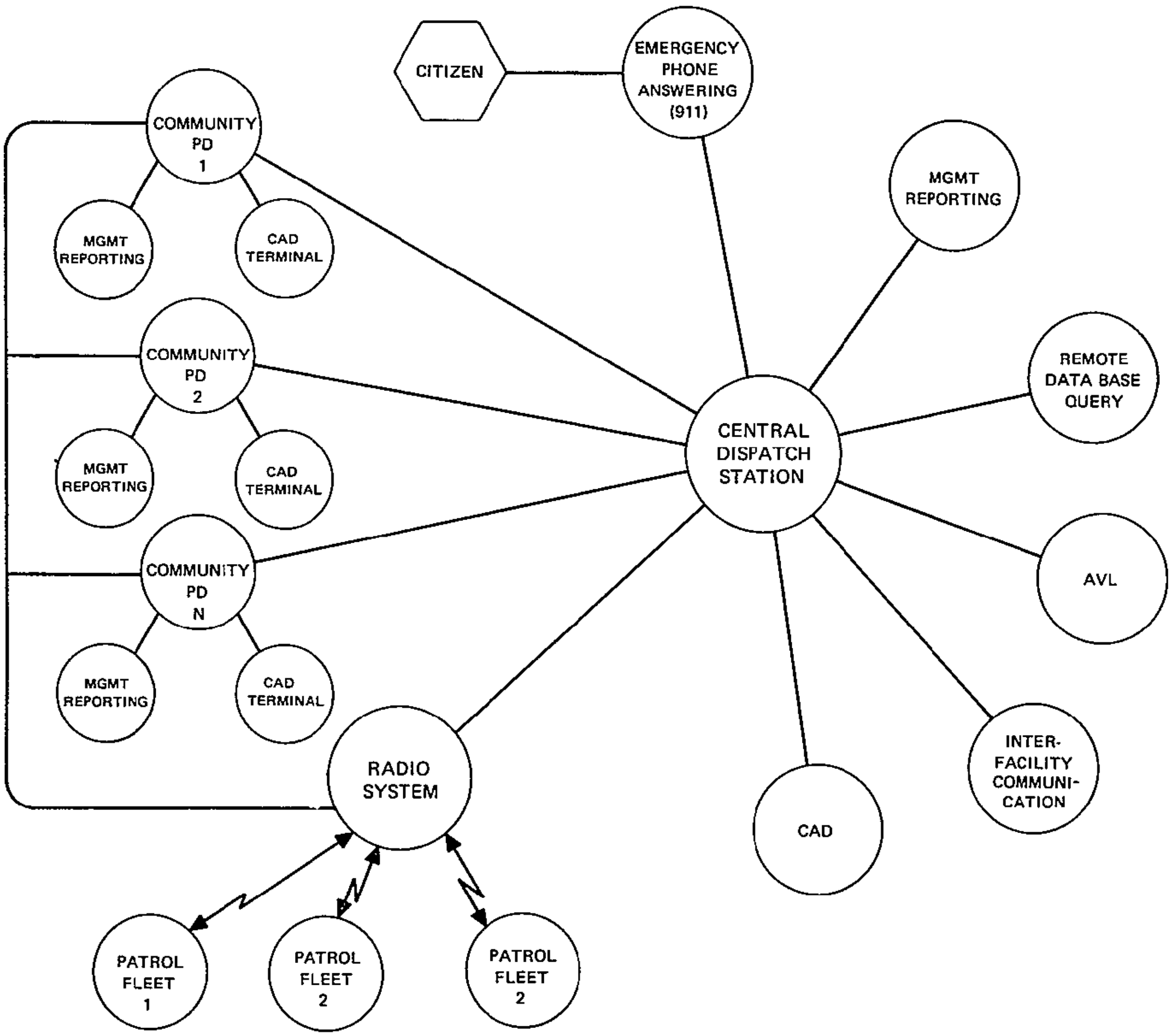


Fig 5 Fully-centralized multi-community command and control

3. PLANNING GUIDELINES: THE PLANNING PROCESS

The process of planning for a new, multi-community command and control system consists of the following steps

3.1 Development of a Legal and Administrative Plan

Development of a legal and administrative framework for procuring and operating a multi-community command and control system is one of the most important, and perhaps one of the most difficult steps in the overall implementation program Agreement must be reached on a large number of important points, and suitable legal and organizational entities brought into being before the project can be initiated Major points to be addressed include

- Project management structure
- Capital financing plan
- Operating and maintenance cost allocations
- Radio frequency allocation
- Central vs decentralized dispatching

Normally all details of the legal and administrative plans will not be resolved before the project is started, but at some point, before major procurements are initiated, it is essential to set up the operational legal entity Planning the form and functions of this entity, and getting agreement and approvals from the several communities in the program is time-consuming, and should be started as early as possible

An example of legal and administrative plans for a multi-community command and control system program is given in Chapter 4

3.2 Analysis of Requirements

In this basic step the planner establishes what the new system must do If he is considering an integrated system, he will need to examine each aspect of police command and control automation and determine 1) does this department need it?, and 2) if so, what quantitative performance requirements can be established for it? Some of the automated functions that should be considered in the initial analysis of requirements, and basic questions related to each, are listed below.

- Digital Communications
  - share the voice channel or use a separate channel
  - mobile terminals with printers or with displays only
  - how many function keys on mobile terminals
  - what "canned" messages should be provided
  - will the mobile terminals have direct query capability to remote data bases
- Computer Aided Dispatch
  - redundant computers or single computer
  - how many supervisory positions are needed for CBO and dispatch
  - separate operator position for remote data base queries, ambulance and tow requests, or have dispatchers handle them
  - patrol unit status updates by voice or automated by digital status messages to computer
  - how will the automated system be used by officers in preparing their end-of-shift reports
  - what management reports will be required of the system
  - will dispatchers have single or multiple screen displays
  - will the system include a geographic file, a prior history file by address, a temporary situation file
  - will the computer recommend patrol units for dispatch or will the dispatcher select the unit with no indications from the computer
- Automatic Vehicle Location
  - what type of system (dead reckoning, signpost, triangulation) should be considered

– what location accuracy is needed to achieve a significant improvement

– what will be the effect on officer morale

The above questions are intended merely to suggest the types of questions that need to be asked and answered in a requirements analysis. Naturally, in all cases the major questions should be

- What other departments have had experience with this kind of automation and what have their observations been?

- How much will it cost and how long will it take?

- Can the system be procured jointly with other agencies or other communities?

Requirements analysis is discussed in detail in Section 5.

3.3 Selection of a System Configuration

Final selection of a system configuration is typically made after the requirements analysis has led to tentative design of a configuration, followed by a cost/benefits analysis that suggests modifications to the requirements and therefore to the configuration. Some of the questions listed above under requirements analysis are basically configuration questions, indicating how closely requirements and system configuration are related. Several iterations of the system definition process are usually required before a final configuration is selected. It can be expected that the process will be longer and more complex if multiple agencies or communities are involved. Development of design concepts is discussed in Section 6.

Once a configuration has been selected, it is possible to prepare detailed specifications for the system to be procured. This technical aspect of the procurement is often subcontracted to an outside consulting firm with detailed knowledge of available hardware and its characteristics, and with experience in designing similar systems If a multi-stage implementation of the system is planned, care must be taken to include in the specifications the different levels of performance associated with the different stages of implementing the system.

3.4 Preparation of the Implementation Plan

Only when a detailed implementation plan has been prepared is it possible to estimate with any certainty the total costs associated with implementing an automated command and control system. Such a plan identifies each activity that is required to produce a completely installed and checked out system with trained personnel to operate it and well-defined procedures for all anticipated modes of operation Each activity is associated with a starting and ending date, and the relationships between activities (i.e , which activities must be finished before certain others can start?) are defined It is especially important to identify the functions that must be performed by the department itself or other city government personnel, this assures that the required personnel are available when needed.

Specific guidelines for preparing an implementation plan are given in Section 7.

3.5 Cost/Benefit Analysis

The decision by communities to enter into an agreement to implement a cooperative command and control system will be strongly influenced by an overall evaluation of costs vs benefits, particularly firm or "hard" benefits that are visible to agency planners and managers in the form of reduced costs. While many advantages for a cooperative system can be cited, relatively few are easily converted into dollars and cents savings, particularly factors dealing with response time, officer safety, and community relations. Our approach will be to compute dollar values where possible, and to indicate qualitative benefits that are claimed or have been demonstrated.

As an example of a particular case of a combined multi-community police command and control system, Chapter 8 presents some cost-benefit data on a system that is now in the process of being implemented by a consortium of several cities.

4. PROJECT MANAGEMENT AND JOINT POWERS AGREEMENTS FOR MULTI-COMMUNITY SYSTEMS

The many advantages to small- and medium-size communities of forming a cooperative multi-community police command and control system are discussed elsewhere in this document They can be briefly summarized as

- A modern automated system can be used, one that would be beyond the means of any one community
- The forces of the individual communities can be applied more effectively both to their own and to cross-jurisdictional operations
- Available radio frequency spectrum can be used much more efficiently
- Significant savings are possible in operating costs, especially salaries
- Federal grants to support command and control automation are more readily available to such combined operations than to individual small- and medium-size communities

The purpose of this chapter is to point out and discuss some of the legal and administrative structures that must be formed, and organizational difficulties that must be overcome before these advantages can be realized. This task constitutes the single most difficult step in implementing a multi-community command and control system The examples of project management structure and joint powers agreements presented in this chapter were developed and employed by a consortium of communities for the above purpose, and should be of significant help to those planning a similar project

4.1 Organizing for a Multi-Community Project

The technology for implementing such systems is available today, and there are several contractors who can analyze the requirements in a given case and produce a satisfactory detailed system design Creating the legal and administrative framework for procuring and operating the system, however, is a task that must be carried out by the communities themselves. Agreement must be reached on a great number of points, both large and small. Some of the major points that must be resolved are.

- A new legal entity, separate from any of the participating communities (but under their control), must be created This is not only advisable for efficient administration, but essential because frequencies can be assigned only to a legal entity and federal grants can be made only to such a single body – not to a collection of independent communities.
- Procedures for creating, financing and governing the new legal entity must be defined and agreed upon Since the different communities will have different sizes, different terrains, different tax resources and different crime rates, it is not easy to reach agreement on what support is to be provided by each and what services each is to receive.
- Radio frequency allocations now held by the individual communities must be assigned to the new agency. What frequencies are to be assigned (police- only, police and fire, other, all or part, etc) is a subject requiring extensive discussion Provision must also be made for disposition of frequencies allocated to the combined agency if one of the cooperating communities chooses to withdraw
- Centralized dispatching center should use civilian dispatchers, both for reasons of economy and efficiency and because the new agency probably will not have the ability to exercise authority over sworn personnel For small departments now using sworn personnel for dispatching, this change will require some accommodation.
- The change in dispatching personnel is part of the general problem of changing from a small, closely integrated dispatching operation to a larger, physically and organizationally more dispersed operation. Such a change is not always welcomed by all parties, and considerable discussion is likely to be required
- Each community must retain command authority over its patrol force. Provisions need to be made in the design of the system for each community to monitor and redirect its forces if necessary.
- The legal structure and administrative procedures of the new agency must be in conformance with applicable state and county requirements and regulations State laws may govern the powers of such joint agencies Some states have mandated

the adoption of the 911 emergency calling number by a given year, and planning for the new dispatching center must reflect this requirement.

If allocations (of radio channels, personnel, financial support, etc.) are to be based on current rates of use it is difficult to agree on definitions of such rates. Different departments keep records in different ways that are not easily compared. Only after the combined system is in operation will it be possible to determine usage rates on a common basis.

Most of the above points are related to the structure and operation of the combined system Another major subject of concern is the process of reaching agreement, selecting and procuring the system, establishing the required facilities, and financing the new system This operation is best viewed as a project, to be handled by standard project management techniques Here we will give some examples of how such a project was managed by one consortium of small- and medium-size cities

A first step in managing such a project (or any project) is to define the phases into which it naturally divides itself, and identify the activities that must be conducted during each phase. An essential part of this phasing is identification of how the activities in each phase will be financed In the case used as an example (and probably in most cases under present conditions), Federal and state financing covers a large part of the costs. This financing is in the form of grants, and the preparation of sound, detailed grant proposals is an important part of the project management. Table 2 shows the project phases for the example used here, together with the projected sources of funds

The table gives only summary identification of the activities listed; most of them are either self-explanatory or the details will depend strongly on the particular case (or both). It may be useful, however, to give a more detailed breakdown of the procurement process. Normally it includes the following set of activities:

(1) List and order the system requirements (this follows from the requirements analysis activity listed under Phase I)

(2) Prepare RFP (Request for Proposals)

(3) Secure approval of RFP

(4) Issue bid package (this is the RFP plus any terms and conditions or other supplementary material)

(5) Establish the evaluation criteria for proposals (this may be done before the RFP is issued and become a part of the RFP)

(6) Establish the procedure for evaluating proposals (who does the evaluating, the schedule, who is the final selection authority)

(7) Evaluate the proposals received

(8) Request oral presentations from bidders to supplement the proposals and to answer any questions arising from them. (The step is optional, but is often very helpful in evaluations.)

(9) Select winning contractor

(10) Negotiate contract with winning contractor

This procedure, more or less abbreviated to suit the nature of the procurement, is appropriate for selecting any of the contractors used in implementing the system. This includes the program management consultant selected in Phase I, who then prepares the RFP for the Phase II procurement and may be retained throughout the implementation period. The contractor selected for the detailed design phase may also manage the procurement and installation phase, or a new contractor may be selected for that phase Since the procurement and installation task normally involves two or more contractors (for communications hardware, computing hardware, software, consoles, etc), the procuring agency has two basic options. It can act as its own prime contractor, selecting separate subcontractors for each major element of the system, or it can select a single prime contractor who undertakes to deliver the complete, checked out system on a "turn-key" basis. Most public agencies use the latter approach to avoid the need for a large (but temporary) increase in staff The program management consultant, or another specialized consulting firm, is sometimes retained to monitor the work of the prime contractor Such firms can often provide a greater depth of technical knowledge in the various disciplines involved than the joint agency can afford.

The relationships between the various phases and tasks of project implementation are illustrated in the following section, which describes the project management structure developed by one consortium of communities for a cooperative command and control system.

4.2 Project Management

The problems and solutions associated with multi-community cooperative command and control system implementation projects make it essential to develop and utilize a carefully planned and effective project management structure, one that is flexible and can readily change from a relatively small staff during start-up phases to a more complex organization as the project progresses through the implementation phase and reaches operational status The project management structure must be responsive to, and be governed by, a board of directors comprised of representatives from the participating communities, and follow the advice of advisory committees made up of user agencies.

The project management structure developed by a group of small- and medium-size cities is presented as an example of how one consortium met its organizational needs. The project staff and its functions during each phase of the program listed in Table 2 are discussed in the following sections.

4.2.1 Phase I Project Staff

Phase I objectives were to accomplish the planning for the entire Regional Communications and Dispatch program and to prepare for the detail system design Activities during this phase resulted in. a Phase II Grant Request, a Request for Proposal (RFP) for detailed system design, a contract augmentation for the Program Management Consultant (PMC), and the initial Program Management Plan.

Phase I was conducted under the organization structure shown on Figure 6. The Regional Public Communications Committee consisted of the city manager or the administrative officer and the chief of police of the participating cities. The Policy Committee consisted of the city manager or administrative officer (or his representative) from five of the seven cities in the consortium The Project Director, the Project Coordinator and the Program Management Consultant were nonvoting participants in the Policy Committee meetings.

The Project Staff consisted of a Project Coordinator, one Administrative Analyst, and a secretary. Technical support was provided to the Project Coordinator by the Program

Table 2. Implementation Phases of a Multi-Community Police Command and Control Project

Phase I Establishing the Project (8 months)	Phase II Detailed System Design (12 months)	Phase III System Procurement and Installation (12 months)	Phase IV System Checkout and Acceptance (7 months)
1 Set up project staff 2 Select program management consultant 3 Prepare program management plan (consultant prepares) 4. Begin drafting a Joint Powers Agreement 5 Analyze and define system requirements (consultant assists) 6 Prepare grant application for Phase II funds 7 Prepare a Request for Proposals for Phase II contractor (consultant)	1 Expand project staff as needed 2 Finalize Joint Powers Agreement 3 Secure necessary approvals from state and local agencies 4 Select contractor for detailed system design 5 Select A&E contractor for design of facilities 6 Develop detailed radio frequency plan	1 Select contractor or contractors for system hardware and software 2 Complete facility construction or modification 3. Telephone company installs telephone equipment 4. Develop staffing plan for operational phase (including any transfers from member communities) 5 Prepare training plan	1. Install mobile equipment 2. Check out complete system 3 Establish operational staff 4. Train personnel 5 Demonstrate complete system 6 System acceptance
Funding (about $50K)	**Funding (about $650K)**	**Funding (about $2M)**	**Funding ($1 25M)**
Federal 75% State 6% Local (cash) 4% Local (in kind services) 15%	Federal 90% State 5% Local Cash 5%	Federal 87% State 5% Local 8%	Federal 90% State 5% Local 5%

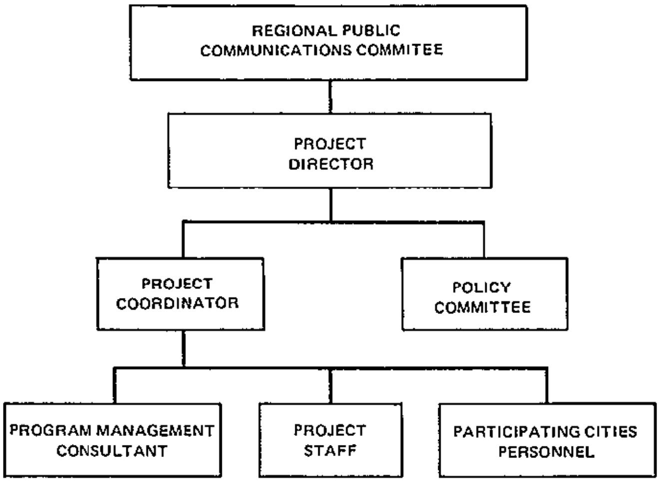


Fig. 6. Phase I project organization

Management Consultant. The cities supplied temporary personnel to assist in the evaluation of the Detail System Design proposals. Personnel from the cities also performed an evaluation of Phase I.

4.2.2 Phase II Project Staff

The Phase II organization shown in Figure 7 is similar to the Phase I organization. The inclusion of Emergency Number 911 and the fire department requirements in the system design resulted in a need for an enlarged project organization.

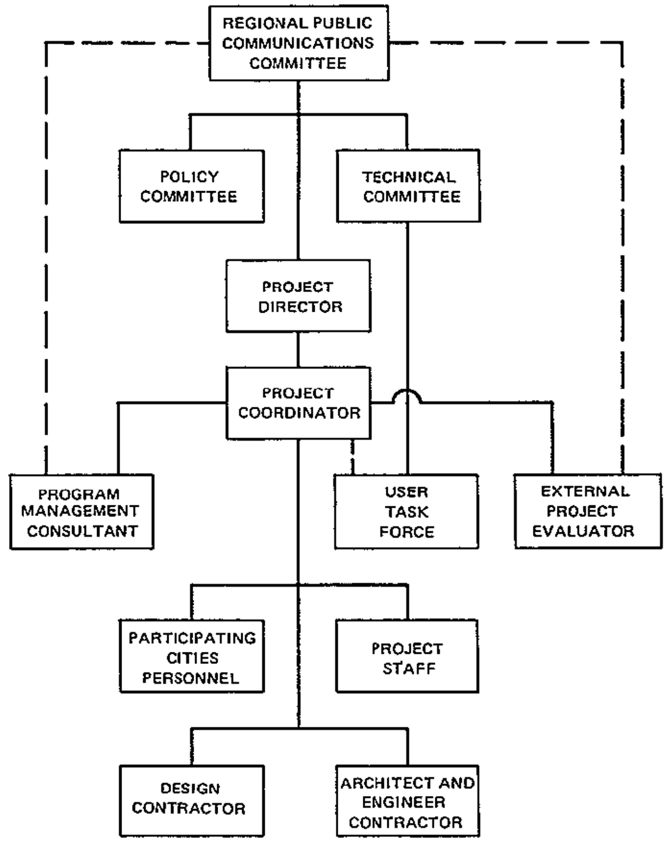


Fig. 7. Phase II project organization

In response to this need, the Regional Public Communications Committee (RPCC) was expanded to include the fire chiefs of each participating city. The RPCC then consisted of the fire and police chiefs and the city manager or administrative officer of each participating city.

The Technical Committee was expanded to consist of the fire chiefs and the chiefs of police of each participating city. The Project Director is the Chairman of the Technical Committee. This committee has two subcommittees· one of fire chiefs and one of chiefs of police. The User Task Force consists of command personnel from each of the police and fire departments Two subgroups formed from the User Task Force provide data to the System Design Contractor on the operational and procedural requirements of each of the police and fire departments. The Technical Committee reviews and accepts the design documents which define systems to implement these operational requirements and operational procedures

The Policy Committee consists of the city manager or administrative officer or his designated representative from each of the participating cities. The Project Director and the Chairmen of the Technical Subcommittees are ex-officio members of the Policy Committee.

The Project Staff for most of Phase II consists of a Project Coordinator, a Senior Administrative Analyst, an Administrative Analyst with a public administration background, an Administrative Analyst with a public finance background, a secretary and a clerk typist.

Personnel from the participating cities' staffs supplement the Project Staff in both administrative and technical matters. matters.

The Program Management Consultant supplies technical support to the Project Coordinator because of the wide variety of technical expertise required and because staff budget limitations restricted the total technical complement of the Project Staff. This support consists of assistance from a number of technical specialists.

In addition to the above changes, the State Division of Communications agreed to serve as the external evaluator for the project. This arrangement provided the Project Coordinator and the RPCC with an objective evaluation of the progress of the project as well as a useful critique of the performance of program management.

4 2.3 Phase III Project Staff

Prior to start of Phase III, the project operated without a Joint Powers Agreement, but it was recognized that the project could not continue into the implementation phase without establishing a legal entity or Authority. As events progressed, the Joint Powers Agreement was executed after the start of Phase III. This cleared the way for implementation of the system, but the delay in executing the Agreement created another problem in that one of the cities became the Grantee for Phase III funding rather than the Authority. There is little precedent for changing a grant from one subgrantee to another, and there may be difficulties and delays in effecting such a transfer.

The organization of the Regional Public Communication Authority is shown in Figure 8. The Board of Directors consists of one city council member from each of the participating cities. In addition, the Chairpersons of both the Executive Committee and Technical Committee serve as ex-officio members The Executive Director acts as Secretary to the Board.

The Board is the designated governing body for the Authority and, as such, has all powers, duties and responsibilities enumerated and provided for in the Joint Powers Agreement.

The Executive Committee consists of the city manager or chief administrative officer of each member city. In addition, the Chairperson and Vice-Chairperson of the Technical Committee and the Executive Director serve as ex-officio members. The Committee provides guidance for the operations of the Authority within the guidelines of the Joint Powers Agreement and in compliance with directives from the Board of Directors.

The Technical Committee consists of the police and fire chiefs from each of the participating cities. In addition, the Executive Director serves as an ex-officio member of the Committee The Committee functions as a technical resource and review agent for the Policy Committee

The Executive Director is responsible for the implementation of technical and administrative objectives of the Project. The Executive Director, appointed by the Executive Committee, serves as Secretary to the Board of Directors and is an ex-officio member of the Executive Committee and Technical Committee.

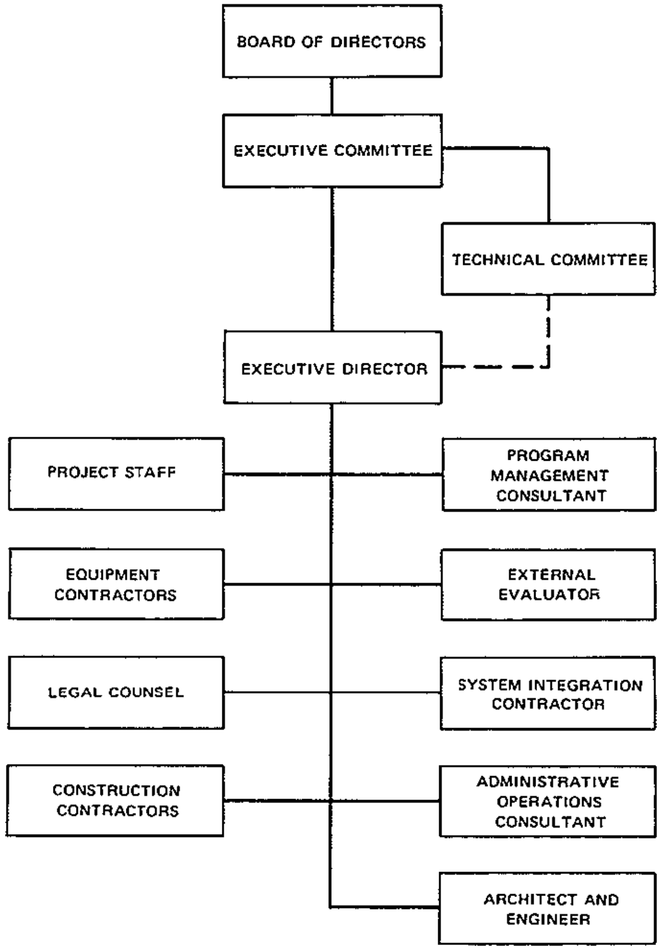


Fig. 8. Regional Public Communications Authority organization chart

The Project Staff provides management, technical, operational, and organizational support to the Executive Director The Program Management Consultant provides technical and program management support to the Executive Director, monitors activities of the System Integration Contractor, and identifies potential technical, operational, and scheduling programs

The External Evaluator serves as technical advisor and assists in the monitoring and evaluation of the Project

The System Integration Contractor ensures that the subsystem interfaces are clearly defined for the Equipment Contractors, checks that the deliverable equipment and software are in conformance with total system needs, and assists in defining potential system problems to facilitate solution. The Equipment Contractors provide various types of equipment and software that meet or exceed specifications developed for such equipment and software by the System Design Contractor during Phase II.

The Legal Counsel provides guidance for the drafting and reviewing of vendor and consultant contracts and other agreements The Administrative Operations Consultant provides assistance in designing and implementing such administrative systems as are necessary for the administration of the Authority.

The Architect and Engineer prepares the drawings and specifications, the primary radio site, and the back-up radio site for the construction of the Regional Communications Center. The A&E will also monitor the work of the Construction Contractors. The Construction Contractors will modify the building and/or sites for the Regional Communications Center and the main radio sites

The current Project Coordinator will remain with the Project on a part-time basis as the Interim Project Coordinator to facilitate the transition and to assist the new Executive Director

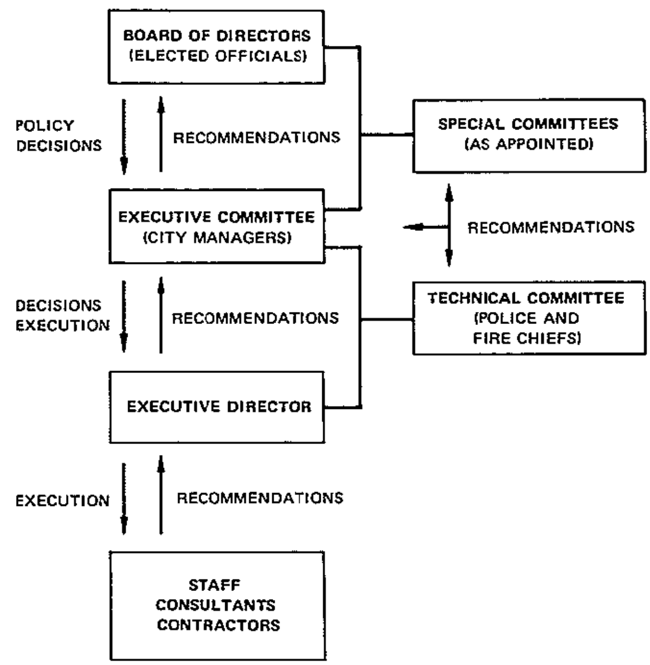


Fig 9 Organizational lines of authority

4.2 4 Phase IV Project Staff

The organization for Phase IV will be very similar to the Phase III organization. The services of the Architect and Engineer, the Construction Contractors and the Administrative Operations Consultant will not be needed and, therefore, will not be part of the organization.

The basic project structure, and the relationships between its elements for decision making, preparation of recommendations, and execution of directives is summarized in Figure 9.

4.3 Joint Powers Agreements

The experience of the communities in the multi-community system used as an example here suggests that ample time should be allowed for the implementation phase of a new combined command and control system. The principal reason is that extensive discussions will probably be necessary to reach agreement on all the issues that must be resolved Some of the questions that may require extended negotiations are:

- How many members will the governing body of the new agency have? Will the member communities be represented by one vote each, or will their votes be proportional to community size, assessed valuation, use of the system, or some other measure?
- What levels of joint authority will there be below the governing body? How will membership at these levels be determined?
- Will decisions be made by simple majority, or will each community have a veto power over certain classes of decisions? (For example, a small but well financed city may not wish to be forced to accept financial decisions made by its larger but poorer neighbors.)
- Will a member community have to transfer all of its emergency radio frequency allocations to the new agency (if it covers fire and emergency medical dispatching as well as police), or will it be able to retain some channels for its own use? What happens to channels transferred to the joint agency if a community withdraws?
- How will the respective contributions of the member communities to the costs of the implementation phase be determined? By size, estimated use of the system, assessed valuation, or other?
- How will the joint agency charge member communities for its services? By actual use, by population, by assessed valuation, or on some other basis?

- What rights, if any, will employees of the member communities have to similar jobs with the new agency?

To provide some guidance to planners in communities that may be contemplating a combined multijurisdictional police command and control system, we provide in the remaining part of this chapter some answers to the above questions. These are the answers that were found by the communities participating in the system used here as an example.

The legal and administrative framework for the multicommunity system described here is contained in two related documents One is the Joint Powers Agreement that legally establishes the joint agency, and the other is the set of by-laws that define the details of the joint operation. The basic text of the Joint Powers Agreement is reproduced in Exhibit 1. An annotated outline of the by-laws is given in Appendix B. In general, the subjects covered in the by-laws are.

- Membership
- Makeup and operation of the Board of Directors
- Makeup and functions of the major committees
- Functions and duties of the Executive Director
- Finances
- Ownership and disposition of assets, including FCC licenses
- Procedure for amending the by-laws.

EXHIBIT I

JOINT POWERS AGREEMENT

THIS AGREEMENT, entered into on the effective date hereinafter set forth, by and between the public agencies signatory hereto and also those which may hereinafter become signatory hereto (hereinafter "public agencies").

WITNESSETH:

WHEREAS, said public agencies recognize the dire communications congestion problem and the resultant ramifications thereof within that certain geographical region, Area X, and

WHEREAS, the State Legislature mandates the implementation of a uniform emergency telephone number designated "911" by a certain date for use throughout the State, and,

WHEREAS, said public agencies have heretofore determined that the system through which the uniform emergency telephone number service is to be provided should be a regional center responsive to the local needs of the citizenry of said public agencies and,

WHEREAS, said public agencies have heretofore determined a need to establish a consolidated, regional, computer-assisted dispatch operation to best serve the needs of all of the citizens of said public agencies, and,

WHEREAS, said public agencies have heretofore determined that the interests of the citizens of each of said public agencies can best be served by the coordinated use of public safety radio channels, and,

WHEREAS, said public agencies recognize the mutual benefit of a consolidated, regional joint effort for the development, implementation and the subsequent operation and maintenance of such a consolidated regional system; and

WHEREAS, said public agencies desire to consolidate and provide emergency call receiving, dispatching, and related operations, and,

WHEREAS, the cost of developing, implementing, operating and maintaining said consolidated regional system is more than can be borne by one or a few municipalities within the area, and,

WHEREAS, said public agencies have heretofore determined that it is desirable and necessary to collectively direct the management policies and operational practices of said consolidated regional system, and,

WHEREAS, the Government Code of the State authorizes said public agencies to enter into agreements for the joint exercise of any power common to them; and,

WHEREAS, said public agencies possess the power to consolidate public safety services communications by the execution and implementation of this Agreement.

NOW, THEREFORE, FOR AND IN CONSIDERATION OF THE MUTUAL ADVANTAGES TO BE DERIVED THEREFROM, AND IN CONSIDERATION OF THE EXECUTION OF THIS AGREEMENT BY OTHER PUBLIC AGENCIES ELIGIBLE FOR MEMBERSHIP IN THE AUTHORITY HEREINAFTER ESTABLISHED, each of the parties hereto does hereby agree as follows

(1) *Authority Established* Pursuant to the joint powers authorization of the Government Code, an Authority is hereby established to be known and designated as the "Area Regional Public Communications Authority" (hereinafter designated as "Authority") which shall consist of all of the public agencies signatory hereto and those public agencies which may hereafter become signatory hereto. Said Authority shall be an agency and public entity separate[1] from the parties to the Agreement.

[1] Although the new public entity is *separate* from the parties to the Agreement, it is *controlled* by the signatories since the Board of Directors of the new entity is comprised of representatives of the parties to the Agreement.

(2) *By-Laws.* Authority shall be subject to, and shall be governed by, those certain By-Laws[2] hereafter adopted by the unanimous express consent of all public agencies signatory hereto, together with any amendments which may be made to said By-Laws in the manner and means therein set forth.

(3) *Purpose.* The purpose of this Agreement shall be as set forth in the recitals hereinabove and the preamble to the By-Laws. Said purpose shall be accomplished and carried out in the manner set forth in said By-Laws.

(4) *Membership.* Each public agency signatory to this Agreement, and each additional public agency eligible for membership pursuant to the provisions of said By-Laws, which may hereafter sign said Agreement, is a member of said Authority and is entitled to all the rights and privileges and is subject to the obligations of membership, all as provided in said By-Laws.

(5) *Termination of Membership.* This Agreement shall remain in full force and effect as to all member agencies for a minimum of five (5) years from and after the effective date hereof. Thereafter, any party to this Agreement may cease to be a party hereto and may withdraw from membership in Authority by the adoption by its legislative body of a resolution of intention to withdraw and the giving of written notice thereof to the Executive Director of the Authority and to each of the other public agencies signatory to this Agreement at least ninety (90) days prior to the end of the then current fiscal year. Said termination shall be effective at midnight on the last day of said current fiscal year.

(6) *Administration* Pursuant to the provisions of the Government Code of the State, the Authority, as established by this Agreement and as Governed by said By-Laws, shall be the joint powers agency authorized to administer this Agreement.

(7) *Powers of the Authority.* Authority shall have the power in its own name, to make and enter into contracts, to employ agents and employees, to acquire, hold and dispose of property, real and personal, to use and be used in its own name, and to incur debts, liabilities or obligations necessary for the accomplishment of the purposes of this Agreement. However, the debts, liabilities and obligations of the Authority shall not constitute any debt, liability or obligation to any of the individual public agencies which are signatory to this Agreement. Authority shall have the power of eminent domain which power shall not be exercised except with the unanimous consent of all member agencies.

(8) *Amendment.* This Agreement may not be amended, except by written agreement of all the then parties to it, provided, however, that the By-Laws hereinafter adopted may be amended from time to time by the method and means provided therein

(9) *Duration of Agreement.* This Agreement shall continue in effect until terminated by unanimous consent of the then parties to it or until dissolution of the Authority in the manner provided in said By-Laws Upon such termination, or dissolution, the assets remaining, including any surplus money, shall be disposed of in the manner set forth in said By-Laws.

(10) *Enforcement.* Authority is hereby given the power to enforce this Agreement If suit is necessary to enforce any of the provisions hereof, including any provision of the By-Laws, the defaulting member shall pay reasonable attorney fees to Authority as adjudicated and determined by the Court.

(11) *Effective Date of Agreement* This Agreement shall become effective upon its execution by the member.

IN WITNESS WHEREOF, the undersigned public agencies have set their signatures on the respective dates set forth below

[2] See Appendix B for an annotated outline of the By-Laws.

5. ANALYSIS OF REQUIREMENTS

Some questions of a fairly general nature were listed in the previous section under the heading of requirements analysis. In a formal requirements analysis exercise, considerably more detail is required. Nevertheless, such a set of questions can serve as a good starting point for the analysis.

This section will consider the analysis of requirements for an integrated police command and control system. Requirements must be defined for the following elements:

(1) Telephone communications and telephone answering stations

(2) Dispatcher position

(3) Communications channels (digital and voice)

(4) Data processing

(5) Digital communications (equipment to equipment inter-ties)

(6) Display processing

(7) Vehicle location (not necessarily included)

Analyzing requirements in terms of these functions (rather than by technology such as mobile digital communications, computer-aided dispatch, etc.) is appropriate for planning of multi-community command and control systems, since it is relatively easy to determine which functions are to be combined and which will remain in the separate communities.

In addition to the requirements for these individual functions, a set of requirements may be defined for the system as a whole. These are in general indicated in the companion manuals in this series for each type of new technology, and are summarized briefly in this section.

Since, as noted previously, response time is affected by all elements of the system it is possible to use this as one quantitative requirement for the overall system. Such requirements are usually stated in statistical terms, for example "The maximum average waiting time for a call to be answered by the CBO shall be 2.5 sec, and no more than 5 calls in 1000 shall receive a busy signal." Similarly, communication channel capacity requirements can be stated in terms of waiting time under maximum anticipated load conditions. Both the percentage and the time can of course be varied to reflect the conditions in a given department. The value of a measure like this is that it reflects the performance of all the links in the dispatching sequence adequate numbers of trunk lines and complaint board operators, efficient automated support to the CBO, rapid transfer of incident data to the dispatcher with the computer taking over all routine operations and maintaining patrol unit and incident status; patrol unit status kept current by digital status messages processed by the computer; less voice channel congestion because of routine digital messages, shorter travel times because of improved allocation of patrol units, better beat design, and/or better information on vehicle location.

In the case of multi-community command and control systems, it is usual for the patrol units to remain within their respective jurisdictions (except in special cases) and it is essential that they remain under the authority and control of the respective police departments. Only the receipt of calls for service and dispatching function are centralized. Under these circumstances response time requirements, if specified, would be limited to these functions.

Other constraints or requirements can be placed on the overall system, but these are generally associated with one new technology and are covered in the appropriate companion manuals. The following subsections will discuss the requirements analysis for each of the functions identified above.

5.1 TELEPHONE COMMUNICATIONS

5.1.1 Functions

The functions to be provided by the telephone system are listed in Table 3. It is of interest to note that some smaller departments have provided for cross-patching of an emergency call directly to the assigned patrol unit's radio channel enabling the calling citizen and the officer in the patrol unit to converse directly. This is a useful feature for the caller and the officer, but could give rise to trunk line and radio channel congestion unless carefully monitored

Planners anticipating the implementation of the 911 emergency number in their areas should assume that if the police department is the answering point for 911 calls, the average yearly call rate will increase by 25% to handle the fire and emergency calls. It may also be expected that call rates will increase by an additional 10% or more because of the fact that it will be easier to place emergency calls (e g., no charge from coin telephones).

Table 3. Functional Requirements for Telephone Communications

Item	Requirements
Trunk line terminations	1. Enough trunk lines to support a service grade (probability of blocked call) of p = 0.001 (one per thousand) for the calling number (911 or regular 7-digit number)
	2. Terminations for the installed voice or digital alarm systems
	3 Terminations for dedicated voice and digital tie lines with operations centers, other agencies, radio transmitter/receiver sites, remote data bases, police/fire call boxes, and any special sites such as permanent locations for mobile command posts
Automatic Call Distribution (ACD) set	1. Provide balanced call distribution to the planned number of CBO consoles
	2. Provision for call overload signalling
	3. Provision for collection of call statistics
	4. For 911 systems, signal separation of voice and digital ANI/ALI data
	5 For 911 systems, line control signal separation

Item	Requirements
Voice log recording	1. Recording for log purposes of all calls processed at the dispatch center
	2. Instant playback as needed for each work station (CBO and dispatcher)
Internal intercommunications	1. Intercom channels among all work stations
	2. Capability for supervisor work stations to patch in to any selected work station (i.e., parallel operation)
Line controls and switching	1. Provide at each work station (CBO and dispatcher) the controls and displays required to allow the operator to select voice radio or telephone lines, establish multiple connections, or hear instant playback from the voice recorder
	2. Provide for rerouting of emergency and interagency tie-lines to specified backup points in the event of failure of dispatch center communications

Another point to be considered in connection with the 911 system is that the telephone company will have to separate calls along jurisdictional boundaries, if a cooperative multijurisdictional system is set up, there will be fewer boundaries requiring separation and the costs should be lower.

Other telephone system features that are commonly associated with the 911 system are line control features (calling party hold, re-ring, and forced disconnect) and the ANI/ALI feature. The line control features should improve the handling of calls by the CBO, and the ANI/ALI feature can be incorporated into an automated command and control system in such a way as to eliminate the necessity for the operator's entering the call-back number and address on the incident record, the computer can make this entry automatically from the ANI/ALI data provided by the telephone company in digital form. It has been found that 80 to 90% of reported incidents are at the address from which the call is made or within a few doors of it. The ANI/ALI feature should also reduce the volume of crank calls, since callers will know that their location is being recorded.

Telephone system functions are shown in Figure 10. The functions shown are briefly described below.

- *Patch Panel* – A terminal block assembly where all telephone circuits and private tie-lines terminate for distribution and interface to other telephone equipment.

- *Voice Log Record/Playback* – Magnetic tape recording of all circuit lines selected for answering by the dispatch center operators. The voice log recorder typically provides for continuous 24-hr recording of as many tracks as there are CBO work positions and an additional track for serial time-date code recording. Tape log playback typically is an off-line operation requiring tape searching to a specified period of time for voice track playback. The voice playback unit and the time code translator/tape search unit are also used for playback of the radio subsystem's voice log tapes.

- *Time Code Generator* – A time standard that provides the serial time-date signals for the telephone and radio channel voice log recorders This unit also provides parallel date-time data to the system processors and digital data multiplexer/demultiplexer for event synchronization and time tagging of messages.

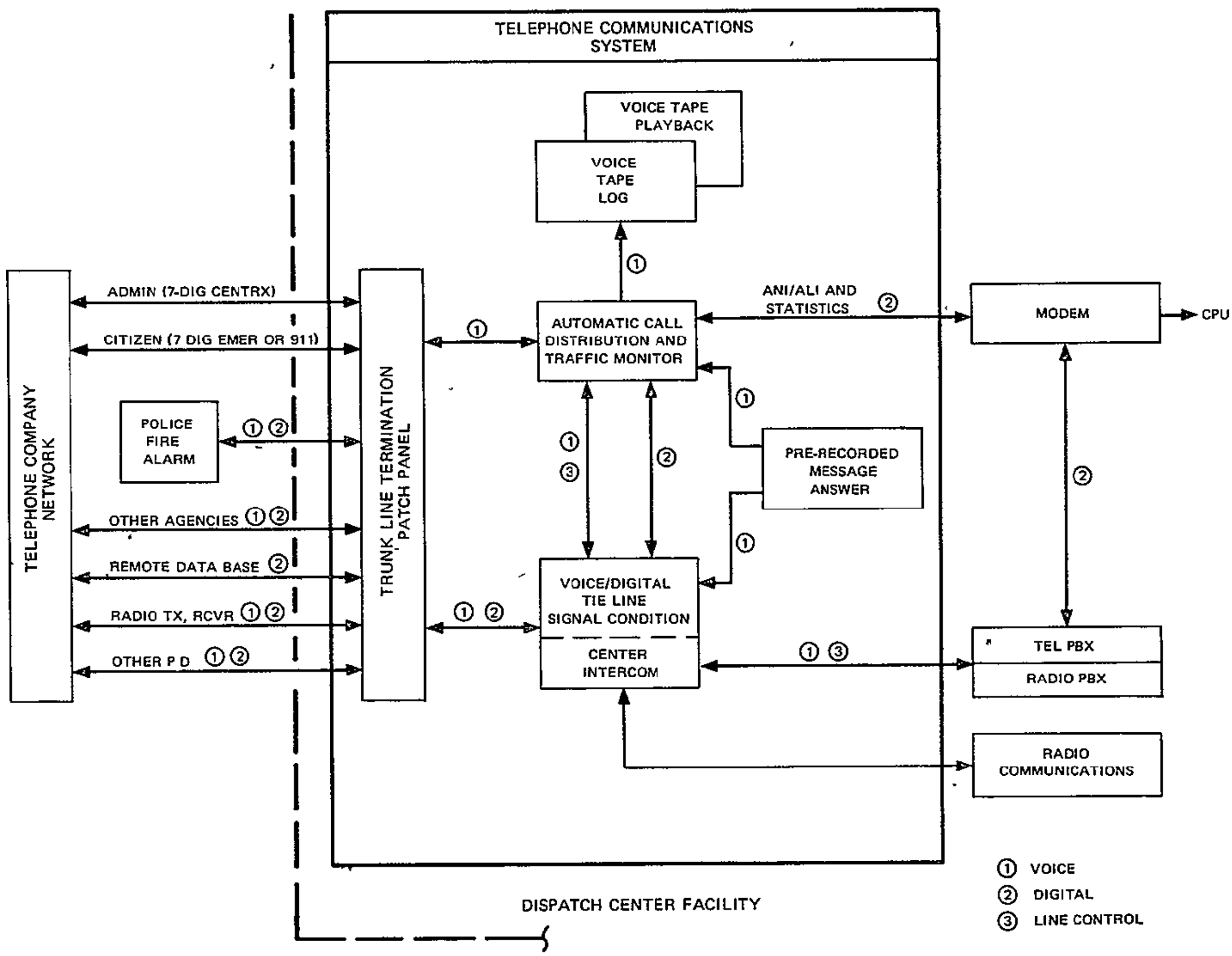


Fig. 10. Telephone communications

- *Automatic Call Distribution (ACD)* – ACD is a computer based programmable electronic switching system with the following characteristics

  (1) Load balancing call distribution among the active operator consoles or to external centers.

  (2) Automatic record keeping and traffic statistical analysis for all voice/digital lines

  (3) Detects and separates voice from digital ANI/ALI preambles for transfers to CAD and operator displays

  (4) Overload call alert signaling to operator consoles and control of automatic playback overload conditions messages to callers on temporary hold

  (5) Mixed handling of pulse and touchtone dial telephone sets

  (6) Self-test and line test

- *Prerecorded Message Answering* – A tape recorder and playback unit under the control of the ACD can be scheduled to give a prerecorded message and accept the citizens complaints during periods of unanticipated heavy call loads due to unusual conditions. During this period of unusual activity the prerecorded message may indicate that the department is aware of the condition and that if there is new information, to record it for CBO review. This type of message can be given easily when a call from the area of the scene is detected from the ANI/ALI data.

- *Voice/Digital Conditioning* – This assembly consists of line amplifiers, tone and volume control for interfacing the operator's work position voice/listening equipment with the telephone trunk circuits. Signal conditioning for digital teletype and high speed data modems are included to interface the data processing equipment with the tie-lines to other facilities.

- *Work Position Equipment* – Typically all work positions are equipped with full telephone capabilities through a telephone company instrument or custom mode push-button lighted controls to select tie-lines, 7-digit dialing, administrative (center) police/fire call-box or 911 calls via the ACD. The dispatch and supervisory consoles typically include a similar lighted push button for radio channel selection as described for the telephone.

All consoles in a modern system include an instant record-playback unit to capture all voice traffic (telephone-radio-intercom) for playback to the operator on demand.

Telephone operations in an automated command and control system are very similar to those in a manual system, but advent of the 911 emergency number system will change the operations significantly in any case, as already indicated. Some of the ways in which telephone system operations are affected by the change to an automated system are the following.

- Statistics on incoming calls and other telephone usage are collected automatically.

- With a 911 system, provision must be made for sorting incoming calls (police, fire, emergency medical, other) and relaying them to the appropriate points.

- With a 911 system, added capabilities are available (ANI/ALI, line control features) and can be incorporated into the automated system.

- Special provisions must be made for a backup answering capability if the central answering facility is unable to function for any reason

In the case of the 911 system, the police operator may be the one receiving all emergency calls (75% of emergency calls are for police) and relaying the fire and emergency medical calls to other points. Alternatively, there may be a special 911 operator who relays police calls to the police complaint board operator (CBO), after which the procedure is the same as illustrated in Figure 1.

The discussion in this manual will be based on the assumption of a separate CBO and dispatcher Smaller police departments (with a low rate of calls for service and not more than 10 to 20 patrol units) are able to operate with the CBO and dispatcher functions combined. The considerations involved are discussed in the companion volume on Computer-Aided Dispatching. That document also discusses the situation in which there are two levels of CBO, with special CBO positions to handle long calls or a separate information operator to handle data base queries The normal configuration for medium to large police departments is separate CBO and dispatcher, with one level of CBO answering as shown in Figure 1. For a multijurisdictional dispatch center serving several small communities, the volume of calls may not be great enough to justify a two-level CBO answering arrangement. If the patrol units have direct access to remote data bases through their mobile digital terminals, a separate operator to relay such queries is not required. If dispatchers are required to relay such queries, however, it may be found desirable to remove this load from them by establishing a separate operator console for the purpose.

An aspect of telephone system operations that requires consideration during the planning stage is a backup system for answering calls for service in the event that the dispatch center is unable for any reason to handle them. The relative costs and benefits of alternative backup systems should be analyzed as part of the planning process. Two possible arrangements are:

- The telephone system can be duplicated at another location, with parallel trunking of calls on a continuous or selective patching basis from the telephone company exchanges. Some dispatching capability, manual or automated, should also be provided at the backup facility.

- Arrangements can be made with the telephone company to intercept calls to the dispatch center during any periods when it is not operational. The intercepted calls can be answered by a prerecorded message at the telephone exchange giving alternative numbers to call by area of origin of the call, or they can be automatically rerouted to selected precinct backup answering points. If a mobile command post is deployed to substitute for the dispatch center, the telephone exchange can reroute the calls to the location of the mobile command post. This may prove to be the most cost effective option, since the mobile command post and prepared sites for it may be required for other reasons. Another possibility for rerouting calls from the telephone exchange is to route them to local precincts, from which they can be routed over existing land lines or microwave links to another dispatch center

5.1.2 Quantitative Requirements Analysis

Procedures for determining the numbers of CBO consoles are given in detail in the CAD manual, but will be reviewed briefly here to illustrate the effects of a combined multicommunity dispatch center. Significant savings can be realized by such a combined system.

Using the example in the CAD manual, we assume a total system with the following parameters

- Busy-hour call rate of 200 calls/hr
- Average call duration 150 sec (includes time spent in queue)
- Mean service time (time operator is talking to caller) 110 sec
- Maximum average waiting time of 2.5 sec
- Maximum percent of calls receiving busy signal 0.05 (5 per thousand)

The trunk work load in load units is calculated from the expression

$$\text{Work load units} = \frac{\text{peak call rate (calls/hr)} \times \text{call duration (sec)}}{3600\ \text{(sec/hr)}}$$

For the given case we have

$$\frac{200 \times 150}{3600} = 8.33 \text{ load units.}$$

Now from Figure 11 we find the number of load units (8.33) on the horizontal axis and the maximum percent of busy calls on the vertical axis (the lowest line in this case). We then take the nearest curve to the right (the curves represent the required number of trunk lines), which is 17. This is the number required to meet the specifications under peak load conditions.

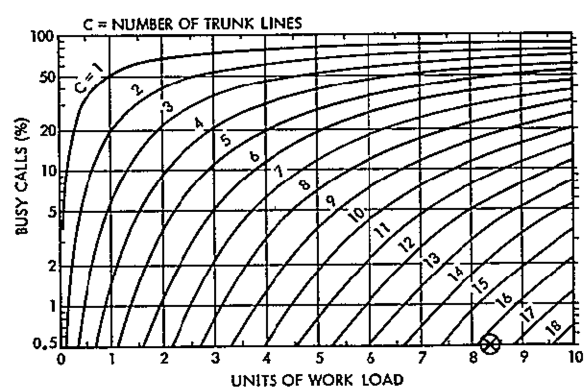


Fig. 11. Trunkline design

The numbers of CBO positions[3] is determined similarly. The parameters to be calculated are the delay units and the operator work load. Delay units are calculated from the expression

$$\text{Delay units} = \frac{\text{mean waiting time (sec)}}{\text{mean operator service time (sec)}}$$

For our case this becomes

$$\frac{2.5}{110} = 0.023 \text{ delay units}$$

Operator work load is calculated as

$$\text{Work load units} = \frac{\text{peak call rate (calls/hr) x mean service time (sec)}}{\text{3600 (sec/hr)}}$$

or in our case

$$\frac{200 \times 110}{3600} = 6.11 \text{ work load units.}$$

The number of operators required is then determined from Figure 12. The 0.023 delay unit line runs horizontally near the bottom of the figure, and intersects the vertical 6.11 load unit line between the curves for 10 and 11 operators. We therefore take 11 as the number of CBO positions required.

[3]As noted, we are assuming a single level of CBO answering For the case of a secondary operator to handle long calls, see the CAD manual.

With these figures as a basis for the given total load, we can now consider the requirements for separate jurisdictions with the same total load. Let us assume that there are five adjacent communities with the load equally distributed among them (40 calls/hr each) and the same delay requirements.

For each individual community we have

$$\text{Trunk work load} = \frac{40 \times 150}{3600} = 1.67 \text{ load units.}$$

From Figure 11 we find that this requires 6 trunk lines (nearly 7) to meet the specification. For all 5 communities the requirement is then 30 trunk lines, compared to 17 (with a considerable margin) in the combined case. For the number of operators we have for each community (delay units are the same, namely 0.023)·

$$\text{operator work load} = \frac{40 \times 110}{3600} = 1.22 \text{ load units.}$$

From Figure 12 we find the required number of operators is 5, since the intersection falls between the curves for 4 and 5 operators For the 5 communities, 25 operators will be required.

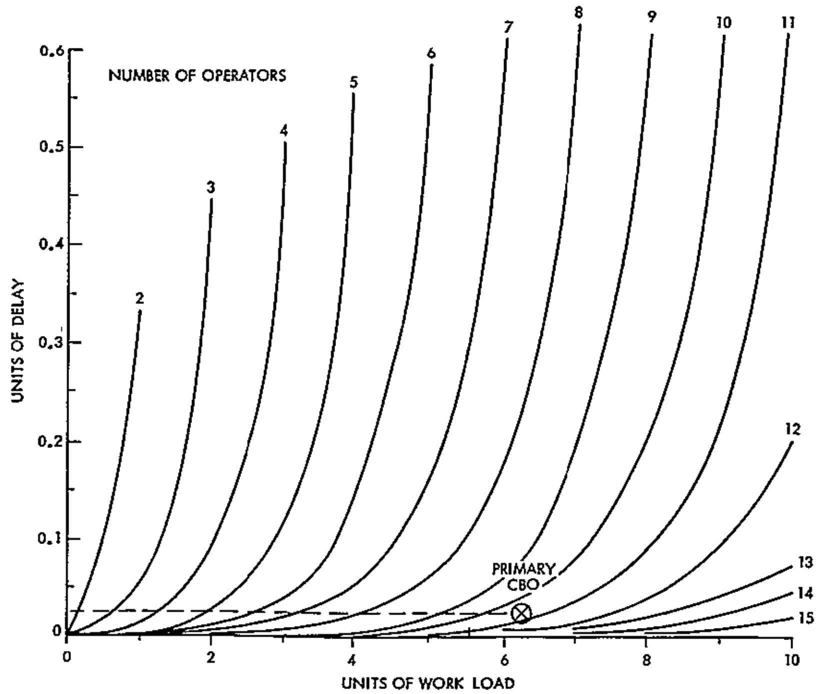


Fig. 12. Complaint board operator position requirements

In summary, we have:

	5 separate communities	multi-community system
Number of trunk lines	30	17
Number of operators	25	11

Not all of the indicated savings can be realized, since it will be necessary in the combined case to have five tie lines connecting the separate departments with the dispatch center (or four if the center is located in one of the departments) On the other hand, these tie lines may already be in existence for intercommunity coordination In the case of the operator positions, it will probably be necessary to have one operator remain in each department to handle local requirements such as walk-ins and calls transferred from other agencies. Even with this requirement, there is a net reduction of 9 (or 10 if the dispatch center is located in one of the departments) operator positions These are significant savings in recurring operating costs of the CBO function

5.2 Dispatcher Position

5.2.1 Functions

The dispatcher is at the core of the police command and control operation, responsible for coordinating the patrol forces to meet the rapidly changing demands for police service. This coordination primarily takes the form of receiving and transmitting messages that fall into five basic categories

- Messages involving initial assignments of cases
- Messages supporting cases in progress
- Messages supporting units on patrol
- Messages involving case dispositions
- Messages relaying queries to remote data banks and the answers to these queries.

The first category of messages covers the activities of the dispatcher when a case first arrives at the dispatching position finding an available patrol unit, giving that unit the address and details of the case, assigning the unit to the case, and entering this data into the computer through the console keyboard

The second category, supporting cases in progress, includes messages from assigned patrol units such as status changes, requests for verification of address or location of informant, request for backup unit, or additional case information to be entered into the computer file

The third category, support of units on patrol, includes status messages, handling requests to talk to other patrol units, clearing requests for meals, and general administrative functions not related to specific incidents

Those messages related to case disposition include the case clearance messages from patrol units, any comments on the case, and status changes for units involved in the case.

The last category of messages has to do with requests from patrol units, both on patrol and on assignment, for information from remote files; most such queries are for license plate checks or wants and warrants checks

5 2.2 Quantitative Requirements Analysis

Since little information exists as to the maximum number of cases that dispatchers can be expected to handle without undue stress or loss of efficiency, it is difficult to establish quantitative requirements for the number of dispatcher positions, particularly for those using relatively new techniques based on computer-aided dispatching In general, use of CAD may not reduce the number of dispatchers needed at any one time, since a large amount of the dispatcher's time is occupied in talking and listening, neither of which is accelerated by the CAD system itself, although in combination with mobile digital terminals, a CAD system can reduce the average voice message length

As described in the CAD manual, we made video and audio tapes of two CAD dispatch operations, one at the San Diego Police Department and the other at the Huntington Beach Police Department, to provide data on maximum acceptable loadings for these stations. By measuring the dispatcher busy time, that is, talking, listening and manipulating the CAD terminal, during both slack and busy periods, and with as few as 20 and as many as 47 cars assigned to a single dispatcher, we observed that no more than about 25 cases could be handled at any one time. At this level the voice traffic tended to become congested, and dispatcher communications were "compressed" to a minimum, dispatcher busy time reached 67% This case load represents an upper limit, which probably could not be sustained for long periods of time, a lower case load value should be used for design purposes, recognizing that occasionally the design loading will be exceeded for short periods of time during extremely busy periods

The design value for dispatcher case loading was established by conducting simulations of several dispatch station operating modes. These modes included the following procedural variations:

System A	Separate CBO and dispatcher, dispatcher does not handle queries to remote data banks.
System B	Separate CBO and dispatcher, dispatcher handles queries to remote data banks.
System C	Dispatcher takes calls from public, but does not handle queries to remote data bases.

From the point of view of the system planner, the important result of this simulation was that with any of the systems simulated there is a critical point in the case arrival rate beyond which performance degrades seriously either because: (a) the dispatcher is unable to handle the increased load without being subjected to undesirable stress and reducing the level of service and (b) waiting times become excessive, which degrades system performance because patrol units cannot communicate with the dispatcher satisfactorily. Channel utilization could also become a limiting factor at slightly higher rates if these other factors did not impose their own limits.

To summarize, there is a critical case load value that should not be exceeded. Taking into account both the dispatcher busy time limit and the waiting time limit (10 sec), these critical case loads as shown by the simulation are approximately

	Cases per hour
System A	21
System B	11
System C	8

These figures alone would suggest that Systems B and C are about equal, but there are significant differences The channel utilization remained very low for System C at all points because the dispatcher is taking calls from the public, these are relatively long calls and use no channel time at all Note also that in our simulated System C the dispatcher does not handle remote data base queries, as is the case in System B. If the dispatcher had this added load, System C would be out of the question except for very low case loads.

The conclusion is that the first step to be taken to increase the capacity of a dispatcher position is to separate the CBO function from the dispatcher function This not only frees a large amount of dispatcher time, but reduces the stress on the dispatcher because he is no longer required to deal with the public as well as manage his patrol units. He can concentrate on the dispatching job, which has enough stresses of its own in a large command center, without the added stresses involved in taking calls from the public

Another important function of a separate CBO is to filter calls from the public, some fraction of these calls do not require a response from police or other emergency vehicles, but if the dispatcher takes a call directly he must do the filtering at the expense of his other functions. The separate CBO can also improve public relations if a busy dispatcher is unable to give as much time to a caller as the caller would like.

There are two ways in which the handling of remote data base queries can be separated from the dispatcher function. One is to have a separate position for this function This is a relatively simple change to make, and the information operator can keep track of other situations such as tow requests and ambulance requests.

The other possibility becomes available when the patrol units are equipped with mobile digital terminals With suitable software and equipment in the command and control center, queries to remote data bases (normally Department of Motor Vehicles and NCIC, which are already computerized) can be relayed automatically from patrol unit to remote data base and back, with no load on the center personnel

In either case, the simulation results indicate that the capacity of a dispatcher position can be increased substantially by removing this function from it.

It is relatively simple to determine the number of dispatchers needed for a given center. Since the system should be sized to handle the heaviest expected load, the number of cases in progress during one or more of the busiest hours should be counted. This becomes the load to be handled Now the maximum allowable case load per dispatcher is determined, the figures given above from the simulation are good starting points for this determination. The planner can modify these if he feels it is appropriate in light of conditions in his department, or he may have some combinations of functions that does not correspond exactly to one of the three systems modeled

As an example, let us assume the planner expects to have a System A configuration where the dispatcher handles neither calls from the public nor remote data base queries. Our simulations (and our observations) indicate that with this system, one dispatcher should be expected to handle at most 25 cases/hr, which is slightly more than the 21 cases/hr recommended above, based on a maximum waiting time of 10 sec. We will assume that the case load during several busy hours has been counted, with the maximum load to be planned for amounting to 80 cases/hr. The number of dispatchers is then:

$$\frac{\text{Case load}}{\text{Cases per dispatcher}} = \frac{80}{25} = 3.2$$

which means four dispatcher stations will be needed.

The above analysis of dispatcher work loads can be summarized as follows.

- Only in a small department with low maximum case loads is it practical to combine the CBO and dispatcher functions.
- Relieving the dispatcher of the task of handling data base queries makes a significant increase in dispatcher capacity for managing patrol units and monitoring incidents.
- Dispatcher loads should be sized to keep the average maximum busy time to about 50% (with this average, there will be short-term peaks when the dispatcher is well above this figure).

5.3 Radio Communications

Most police departments contemplating the acquisition of a new, automated police command and control system (including a combined multi-community system) will already have a radio communications subsystem in place. The planner needs to determine what new requirements will be placed on radio communications by the new system, and the best manner of meeting those new requirements. This section describes the overall requirements for radio communications as a basis for determining what changes or additions will be needed. Questions affecting this function need early attention because of the sometimes difficult problems of spectrum availability and FCC licensing.

5.3.1 Functions

The principal functions radio communications are required to perform are listed in Table 4. Another way of considering this function is to consider that it must support the operation of four types of networks:

The Dispatch Network consists of the voice and digital channels connecting the deployed field personnel and the dispatch center. It provides for all the normal operations of dispatching, including patrol unit assignment and status messages, data base queries, and support or monitoring during the course of incidents.

The Tactical Network provides for direct communications among deployed personnel without loading the dispatch network. The tactical network is also the main means of on-the-scene coordination of emergencies and unusual occurrences from a mobile command post. Tactical messages are primarily voice, but digital messages may be used occasionally because of the added privacy.

The Emergency Signaling Network is a dedicated channel or set of channels for use by field personnel to transmit an emergency message prior to or in place of a voice message. It is typically a coded digital message identifying the officer needing assistance; the dispatcher then determines the officer's most likely location and dispatches the appropriate assistance.

The Special Functions Network is used by specialized groups of officers requiring special types of communications (command and supervisory groups, special forces, vice, narcotics, and intelligence units). The special functions network serves primarily to provide communications within such groups; communications between a group and other groups would be via the tactical network.

The digital traffic (in any of the networks) can, unlike voice traffic, use one or more channels as required by the load Mixing of functions in digital channels is feasible because the communications processor can readily separate and route different types of messages in accordance with source-destination preamble codes associated with each message.

Modern law enforcement radio communications subsystems normally provide for unique identifier codes to be transmitted automatically whenever the microphone of a mobile unit is keyed for a transmission The identifier can be in the form of a preamble in the voice channel or may be transmitted over a separate channel. In the latter case the mobile unit can queue its ID code for channel access and monitor when the channel is busy

Digital messages are used to supplement the voice link, which remains indispensable in all cases The voice links should be designed if possible to handle the peak message traffic under emergency conditions, when the transmission of digital text messages may be lower than the equivalent voice messages

The channels available to a given law enforcement agency can be assigned to the various functions and networks in accordance with the agency's needs Some channels are permanently assigned (e g., the emergency signaling channel), while others can be dynamically reassigned in accordance with demand. Modern programmable communications processors, combined with multichannel mobile units, provide a high degree of flexibility in radio channel management, making possible efficient use of the available frequency spectrum.

Such network control operations are implemented by a subaudio code on the voice channel or by digital codes on a dedicated network control channel. When the mobile or portable units have multichannel capability and automatic channel scanning, it is possible to have selective addressing of individual units or groups of units, with the receivers of the other units muted. As noted above, the mobile unit ID code that is transmitted automatically when the microphone is keyed can be used as a channel assignment request and placed in a queue if the channel is busy at the moment, with automatic notification when a channel becomes available.

This dynamic channel assignment feature made possible by the programmable communications processor is also applicable to the tactical and special-purpose networks. Channels can be assigned to these functions as needed, using the total pool of assignable channels, or a special channel can be dedicated to these networks for the period of expected need.

For a combined multijurisdictional dispatch system, the feature of selective addressing may be particularly attractive With this feature, dispatch messages to a given community would be heard only by the patrol units of that community and not by all units in the total combined fleet.

The system planner should be aware that current FCC rules allow a law enforcement channel to be assigned exclusively only if it services at least 50 units (portable units count as half units). It should also be kept in mind that channels can be assigned only to some legal entity; this means that a combined multijurisdictional system must establish a separate legal entity for this purpose as well as for other reasons.

It was noted earlier that digital traffic can be assigned arbitrarily to one or more channels, since it can easily be sorted out by the communications processor and routed to the appropriate destinations For example, a given mobile unit digital terminal can transmit a status message that will automatically be routed to the status file of the appropriate dispatcher, and follow this with a remote data base query (say a license plate check) that will be automatically relayed to the remote data base without going through a dispatcher or operator in the dispatch center. The response can also be automatically routed to the requesting mobile unit (although most systems provide for dispatch center printout of such queries and responses for later reference if needed). Digital messages between mobile units (tactical messages) can also be automatically routed to the addressed mobile unit by the communications processor, which detects the addressed unit code and selects a channel for relaying the message to that unit.

Technical advances in hand-held portable units promise to make the same capabilities available for this kind of equipment in the near future.

The emergency signaling network, which as noted should have a dedicated channel, typically relays the emergency message with officer ID through a set of monitor receivers located for optimal area coverage. The message is transmitted from the monitor to the dispatch center and to specified backup reception points for appropriate action.

The radio traffic monitoring equipment, typically computer-based, is essential for efficient radio channel management. It provides the data on channel loading and access delays that serves the basis for programming channel assignment procedures in the communications processor in such a way as to minimize access delays and make maximum use of the available channels.

A microwave backup net was specified in the functional requirements of Table 4 Such a network can be used for normal or backup communications among facilities (e.g., community PDs) in a system, provided it has multiplexing equipment for voice and digital messages. Vans with microwave antennas can be used in conjunction with the mobile command post to provide secure communications while the mobile post is in operation.

5.3.2 Quantitative Requirements Analysis

The quantitative requirements for radio communications are determined primarily, as in the case of the telephone system, by the expected peak rate of calls for service. The parameter of interest is the channel loading percentage, or the percent of time a given channel is actually occupied by message traffic Considering the random nature of radio traffic, a channel loading of 60% is very high and can be tolerated only for brief periods. At this loading, channel access is becoming difficult and there are many delays that reduce the effectiveness of the command and control system and even compromise officer safety.

Analysis of channel loading is a complex subject, it is treated briefly in the companion manual on Mobile Digital

Table 4. Radio Communications Functions

Item	Requirements
Voice Communications	1. Under conditions of peak call rate and maximum patrol unit deployment, provide two-way voice communications between locations in the jurisdiction from selected command and control centers (dispatch center, local precinct, emergency control center, mobile command post).
	2. Provide the above communication capability for dispatching of 50 mobile units or 100 portable units maximum per channel.
	3 Provide at least one clear channel for city-wide tactical operations of mobiles and portables.
	4. Provide one secure channel for mobiles.
	5. Provide for direct radio traffic between mobiles and portables or any combination of mobiles and portables within a range of one mile.
	6. Provide tactical channels as needed for multi-agency coordination of deployed forces.
Digital Communications	1. Provide two-way digital communications from at least 95% of the locations in the jurisdiction between mobile and portable units and selected command centers (see above)
	2 Provide a data rate of at least 120 characters/sec, including digital synchronization, addressing error coding/decoding, and message repeats.
	3. Provide the above capability for dispatch operations with 200 mobiles or portables per channel for a channel contention net or 100 for a channel polling net.
	4 Provide for digital identification of voice microphones in mobiles and portables and for digital emergency signaling Emergency signaling must be on a dedicated emergency channel.
	5 For Automatic Vehicle Location (AVL) systems based on digital transmissions from patrol units, provide the required interface with the AVL equipment in the vehicle.
Tape Logs	1. Provide for tape logging of all voice/digital transactions and for instant tape playback of voice traffic to dispatcher.
Backup Microwave Links	1 Provide microwave link backup to voice and digital land lines including those to primary radio sites.
Radio Channel Monitoring	1 Provide for radio channel monitors to collect statistics on radio channel usage.
Interface Equipment	1. Provide interface switching and signal conditioning between leased telephone tie lines and radio transmit/receive sites.

Communications and will be covered here in summary form A point of major significance for the planner is to determine what fraction of the total message traffic can be transmitted in digital form; this has an appreciable effect on channel loading because digital messages require less channel time and bandwidth than the equivalent voice messages.

The beginning of a channel loading analysis is a study of the existing traffic on a given channel or set of channels. The parameters to be determined are:

(1) Percent of the total available "air time" the channel is actually occupied (channel loading)

(2) Message types (normally status, dispatch messages, queries/responses, and other text messages)

(3) Average length of message for each type

(4) Average number of messages of each type transmitted per hour

(5) Percent of all messages that can be handled in digital form (this is determined from a review of the length and content of each message type)

An example of such an analysis, taken from the Los Angeles Police Department, is given in Table 5. Message

Table 5 Radio Message Analysis

Message Type	No of Messages	Average Duration, sec
Data query response	57	5 31
Status	385	1.71
Dispatching	84	6 74
Other text messages	109	5 51

types and durations were determined from listening to live base to mobile broadcasts over a 1-hr period on a Friday evening

For the hour analyzed here, the channel loading was found by adding all the "air time" used by all the messages and dividing the total by 3600 (seconds in an hour) The loading was 59 2%, which is very high. With this loading, the statistically expected waiting time can be 5 sec or more, which is unacceptably high.

Considering now which messages could be handled in digital form, it is clear that status messages are easily digitized (some simple systems digitize only the status messages). Although status messages are by far the largest in number, their duration is short even in a voice system and in this case they use less than a third of the total air time. A similar tabulation for the mobile to base traffic showed that status messages were 47% of all messages, but used only 18% of the air time Thus converting status messages to digital form can help reduce congestion, but not so dramatically as might be thought

In general, it is possible to consider digitizing not only status messages, but queries and responses and a large portion of dispatch messages. A case of maximum digitization might be one in which all of these message types were digital, with only the fourth category left for voice transmission (this is not a realistic case, but provides a theoretical upper limit of digitization) Taking some typical values for transmission rates (150 characters/sec) system delay (internal delays in the electronics, 0 75 sec here), and message lengths, we would have the results shown in Table 6 These results are to be compared with the previous table, except that the volume of data query response messages has been multiplied by five to represent the increase in this type of message that normally occurs when direct data base query from mobile units is implemented.

The total air time used by this combination of digital and voice messages is 1423 sec or a channel loading of 39 6%

Table 6. Results of Digitization

Message Type	No of Messages per hour	No. of Characters per message	Message Duration, sec
Data query response			
hit	43	100	0 67
no hit	242	25	0 17
Status	385	8	0 05
Dispatch	84	150	1 01
Other text (by voice)	109	---	5 51

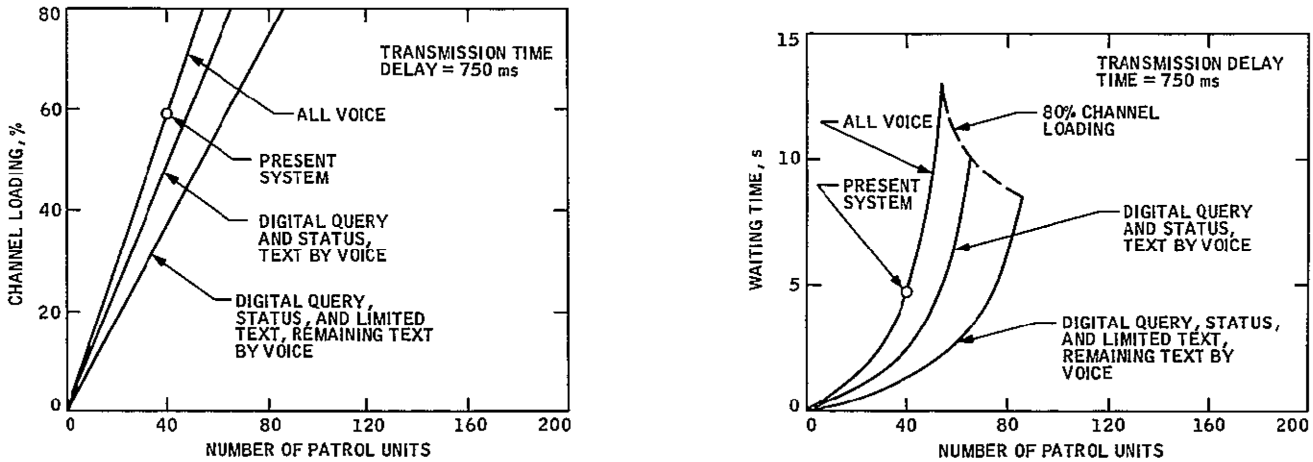
This is to be compared to the 59 2% in the all-voice case, with five times as many query/response messages On the other hand, this is a maximum case of digitization and probably would not be encountered in practice

Figure 13 and Table 7 summarize the effects of converting different portions of radio traffic to digital form, using the type of calculation performed above for the Los Angeles data The graphs on the left show the effect on channel loading, while those on the right show the effect on the critical parameter of waiting time for a mobile unit to gain access to a channel

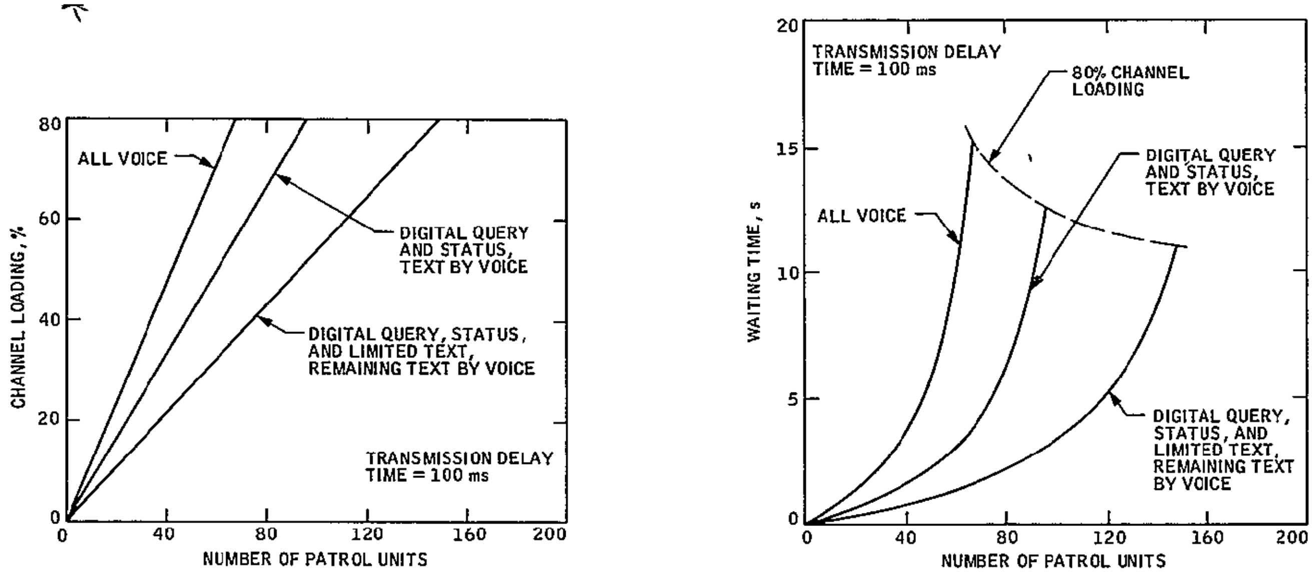
A variable of interest is the number of patrol units that can be handled with the given channel loading or delay time, since this is of major concern to the planner The points labeled "present system" were based on a fleet of 40 patrol units Note that the four graphs at the top all assume that digital traffic is carried on the voice channels on a shared basis; the bottom graphs reflect the results of having a dedicated digital channel. The point of interest from these graphs are.

- With any degree of digitization, system delay time becomes important (compare the (a) graphs with the (b) graphs, the lower curve reaches 40% channel loading with about 50 patrol units in (a), while with the 100-1 msec delay time of (b), it reaches the same channel loading with 80 patrol units). The reason is that digital messages are typically so short that the system delay time is a significant portion of the message duration. Modern solid-state systems can typically attain delay times of 100 msec

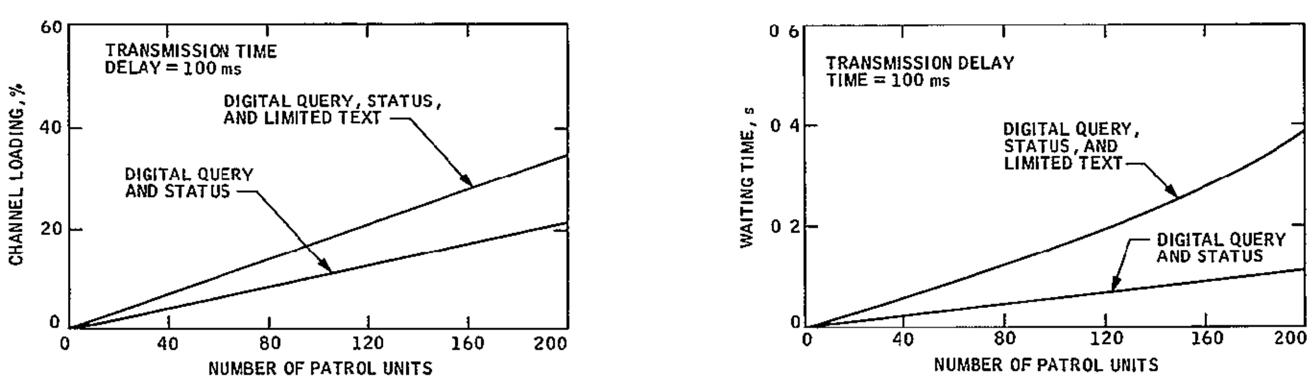
- Channel loading varies linearly with number of patrol units, but delay time is nonlinear and begins to rise much more rapidly as the number of patrol



a. Shared digital and voice traffic (transmission delay time = 750 msec)



b. Shared digital and voice traffic (transmission delay time = 100 msec)



c. Dedicated digital link (transmission delay time = 100 msec)

Fig. 13. Channel loading and waiting time with shared digital and voice traffic and dedicated digital links (base to mobile)

Table 7. Channel Assignment Options

Option	Voice Channel		Digital Channel	
	Loading	Wait Time, sec	Loading	Wait Time, sec
1: Original all-voice channel	0.723	9	–	–
2 Shared voice/digital channel				
a Digital query and status, text by voice	0.530	3	–	–
b Digital query, status, and limited text, remaining text by voice	0.396	1.4	–	–
3 Original voice plus dedicated digital channel				
a Digital query and status, text by voice	0.365	1.9	0.04	<0.1
b Digital query, status, and limited text, remaining text by voice	0.190	0.8	0.07	<0.1
4 Two voice channels	0.361	0.9	–	–

units increases The planner should probably establish waiting time as the limiting parameter

- The effects of digitization are significant; taking the middle graph on the right as an example, and assuming a 4-sec limit on delay time, the number of patrol units the system can handle increases from 40 to about 100 with full digitization.

- Use of a dedicated digital channel dramatically reduces the channel loading and waiting time for digital messages (not that these curves do not reflect the loading or waiting time in the independent voice channel) Waiting time never reaches 0.4 sec even with a fleet of 200 patrol units

The data of Figure 13 are summarized in Table 7, which shows the effects of various levels of digitization on channel loading The points of interest outlined above are underscored by the comparisons drawn in the table

The preceding discussion of channel requirements has not included any load on the subsystem resulting from an Automatic Vehicle Location (AVL) system. Some AVL systems (see Section 5.7) place no requirements on the radio links, while others depend on the transmission of signals on the mobile-to-base link only, and still others place a load on both base-to-mobile and mobile-to-base links. For the dead-reckoning type of AVL system, the patrol unit continuously determines its own location and transmits from 9 to 20 characters of location data either automatically with each status message or on demand from the dispatch center Some signpost systems place about the same small load on the channels Systems that involve polling all the patrol units, however, probably require a separate channel dedicated to AVL functions If polling rates are low, they might be accommodated on the regular digital message channel. In case of some special situation requiring high polling rates, a separate channel could be assigned for the duration of the situation

Dynamic channel assignment by a special communications processor was mentioned earlier in this section The quantitative advantage of such dynamic assignment is indicated in Figure 14, which shows the probability that all channels are busy as a function of the number of channels that can be dynamically assigned in accordance with instantaneous changes in demand. The upper line for a single channel simply indicates that if the channel loading is 30%, then there is a 30% probability that the channel will be busy If there are four channels that cannot be reassigned, there is still 30% probability that all four channels will be busy if the channel loading is 30% However, if we allow channels to be dynamically assigned (i e., any channel can be instantaneously assigned to any message needing a channel at that instant), we can read from the curve for four channels that the probability that all four channels will be busy has dropped to 0.04 (from 0.30).

From the point of view of the planner confronted with the usual problem of insufficient radio channel capacity, this result has two important implications

- If he has more than one channel in use and they are not dynamically reassignable, he can relieve

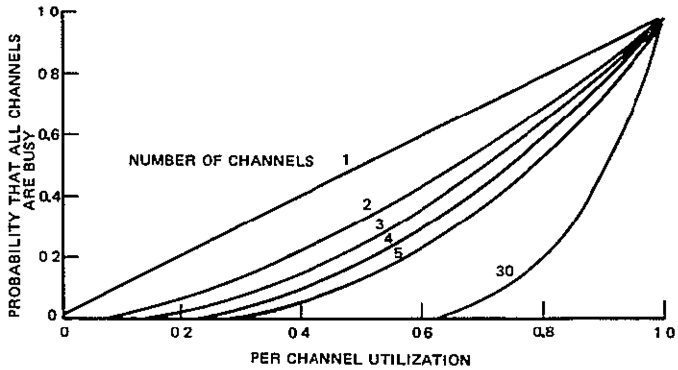


Fig 14. Probability that all channels are busy for various numbers of dynamically assignable channels

channel congestion significantly by providing for such dynamic reassignment (by a computer-based communications processor). Note the large improvement attained by going from one channel to two on Figure 14 (for the 30% channel loading case, the probability that both channels are busy drops from 0 30 to 0.15)

- If adjacent small communities have a single channel each, they can effect a dramatic improvement in channel availability by establishing a combined multijurisdictional dispatch center with access to all the channels Note that the privacy of messages to each community's patrol fleet can still be preserved by selective addressing as described earlier (for digital communications). Taking a case of four communities with one channel each and a peak channel loading of 50%, the probability of having no channel available to a given patrol unit at this peak period drops from 0.50 to 0.18.

5.4 Data Processing

The data processing subsystem consists of the computer, its programs, and the devices connected to it (consoles, printers, communications processor) which perform operations on the digital data. It provides the capabilities for storing, manipulating, and distributing the data used for command and control operations.

The functions required of the data processing subsystem are shown in Table 8. It should be noted that these functions are performed by the software (computer programs) operating in the data processing hardware, not by the hardware alone One of the major advantages of using such a system is that it is easily modified to accommodate changes in procedures, requirements, or equipment simply by rewriting the software; hardware changes are seldom needed even for major modifications in the system.

For a combined multi-community command and control system, the data processing subsystem functions would be essentially the same as those listed in Table 8. The reports output by the system could be tailored to the specific needs of each community, and the incident data could easily be sorted by community so that each would receive reports only on incidents of interest to it. No special requirements are placed on the data processing subsystem by a combined multijurisdictional operation, and the relatively high initial costs of the data processing subsystem can be much more easily justified for such a combined operation than for an individual small community.

Quantitative requirements for the data processing subsystem can be established only on the basis of a detailed analysis of the proposed system design and the numbers of work positions as well as the volume of messages to be handled. In general, current minicomputers have enough capacity to handle the dispatch center operations for a patrol force of 20 units and a peak call rate of 50 calls/hr, this assumes that the data processing subsystem handles the full range of functions discussed here. For the computer-aided dispatching function plus limited additional tasks, a modern minicomputer can handle a load of up to 200 calls/hr and 100 patrol units.

In designing a data processing system configuration, it is often desirable to provide for two CPU's (the CPU is the Central Processing Unit – the computer alone without any peripheral equipment). The second unit not only improves the reliability of the system by being available in standby, but can also be used to increase system capability during normal operations (background processing). Alternatively, the load can be shared between the two units as long as both are operational, and procedures can be established to provide for "graceful degradation" to a slightly lower capability in case one unit fails.

There is a current trend toward distributed processing that may be of interest to the planner considering a new automated command and control system This term refers to the configuration in which the data processing is performed by a number of small units at various locations where it is most appropriate for a given type of data to be processed An example is the so-called "smart terminal" which performs some of its processing (such as display construction, refreshing and control) on a processor in the terminal instead of having the central computer handle these tasks. This trend toward distributed processing is being accelerated by the increasing availability of inexpensive and powerful microprocessors that can be programmed to perform tasks ranging from

Table 8 Data Processing Functions

Item	Requirements
Support Computer-Aided Dispatch (CAD) System	1 Service log-in procedures for incidents received at CBO console, transmitted from patrol units with mobile digital terminals, or entered into the system from other sources
	2 Service digital messages from selected alarm systems
	3 Process ANI/ALI data received on telephone lines for 911 systems and enter the data into the incident log-in and display
	4 Add date, time and serial number to logged-in incident records
	5 Maintain queue of logged-in incidents for dispatcher attention, ordered by priority and time
	6 Check files for duplicates of logged-in incidents and display records of duplicate to CBO if found
	7 Check geographic file for prior history or other data on the given address and display on record
	8 Determine locations of nearest patrol units to incident address from status and location files and display to dispatcher
	9 Process digital dispatch orders entered at dispatcher keyboard for transmission to designated field unit's MDT
	10. Display all Priority 1 incidents on supervisor's (watch commander, tactical officer) console
	11 Add time to incident record when receipt of dispatch is acknowledged by MDT
	12 Maintain file of all pending incidents, including those deferred, with actions included in file record
	13 Maintain status file of all patrol units, grouped by dispatcher, for display on consoles Status change inputs will be direct from MDT's in vehicles
	14 For centers with AVL systems, compute patrol unit locations from received data and enter most recent location in location column of status file
	15 Monitor lines from emergency alarm system and generate appropriate alarms on designated consoles when an emergency message is detected
	16 Monitor elapsed time since last message from each field unit and generate alarm when stipulated period has been exceeded Display last known location of the unit along with unit ID and alarm signal
	17 Process for permanent logging, including time and date tagging, all dispatch transactions
	18 Maintain table of personnel currently signed on
	19 Display on demand a table of outstanding transactions for review by newly signed-on personnel
Support of Automatic Vehicle Location (AVL) System (if AVL is employed)	1 Maintain file of latest known vehicle locations from data received through the AVL system
	2. Update dispatcher status/location files with location data on vehicles under control of each dispatcher
	3 Determine the nearest unit to a given address and supply this information to the CAD support software on demand
	4 Generate and update on designated terminals an area map showing latest locations of patrol units Indicate when a unit leaves the area covered by the map or enters it
	5. Using data from the AVL sensors, provide dynamic tracking of selected units, tabulating the major intersections crossed
	6 On demand, provide for a continuous log of movements of selected vehicles over a given time period
	7 Exercise self-test features of the AVL system and display on selected console the appropriate preventive maintenance schedule or repair request

Table 8 Data Processing Functions (contd)

Item	Requirements
Remote Data Base Query/ Response Support	1 Add time and date tags and serial numbers to all data base query and response messages
	2 Maintain log of all data base queries and responses
	3 Display query format on terminals originating queries and perform edit functions of the input data
	4 Monitor response message for positive responses ("hits") and notify the querying unit immediately Route all "hit" responses with their queries to the printer for printing, and notify selected supervisory consoles of "hits" of selected categories
	5. Negative response messages may be accumulated for 30 sec or until the last data base queried has responded if that is less than 30 sec
Management Data	1 Maintain table of personnel on duty
	2 Maintain activity file of each person on active duty
	3 Provide for tape logging of all transactions
	4 Maintain load statistics for telephone and communications systems
	5 Maintain such special files as are required (emergency situations, etc)
Non-Real Time Processes	1 Provide processing as needed of data handled during periods of manual operation, in order to bring automated system up to date for restart
	2 Provide accesses for updating permanent files, playback of tape logs for specified periods, and modifications of stored contingency plans
	3. Provide programs to generate all types of required management reports based on accumulated data over specified periods
	4 Provide facilities for training of new personnel
	5 Provide facilities for development and test of new software
Files	1. Provide and maintain all system files (intelligence, telephone directory, incident, geofile, personnel, etc) See CAD manual for detailed description of files

very simple to relatively complex. In a dispatch center, the AVL function or the processing of data base queries and responses could be assigned to separate processors, for example.

Distributed processing is also a useful concept where a planner wants to develop a new system in a phased manner over a period of years. A new capability can be added with its own new mini- or microprocessors, without requiring major redesign of system hardware or software.

Quantitative requirements for data processing subsystems are determined from detailed analysis of a particular proposed system. The parameters to be determined from such an analysis include:

- average instruction execution time
- instruction set available with a given machine
- maximum directly addressable main memory
- capability and time for direct transfer of memory data to and from peripherals and communication circuits
- available peripheral equipment (disc storage units, printers, tape units, etc.) compatible with the machine
- Cost per unit of capability (instructions, memory)

Section 5 presents an example of sizing analysis for a multi-community design concept.

5.5 Digital Communications Subsystem

The digital communications subsystem (DCS) provides for communication among all the people in the command and control system, among the different kinds of digital equipment, and between people and the digital equipment (computer, consoles and displays, printers, communications processors, etc).[3] The speed and flexibility with which information can be handled in digital form make possible all of the automated operations associated with automated command and control.

A simplified block diagram of a digital communications subsystem is shown in Figure 15. The communications processor shown in the diagram as a separate box may in fact consist mostly of software within the computer. It can be seen that once a call for service is answered by the CBO, all the processing of an incident is in digital form except for the voice messages between patrol unit and dispatcher and the actual response of the patrol unit to the scene. All records and logs are kept in digital form except for the tape log of CBO and dispatcher conversations. From these logs of digital data, all kinds of routine and special reports and analyses can be produced rapidly and inexpensively by the computer.

[3]Digital radio communications (e g , base to mobile and mobile to base channels) are discussed in Section 4.3.

5.4.1 Functions

The functions of the DCS are summarized in Table 9.

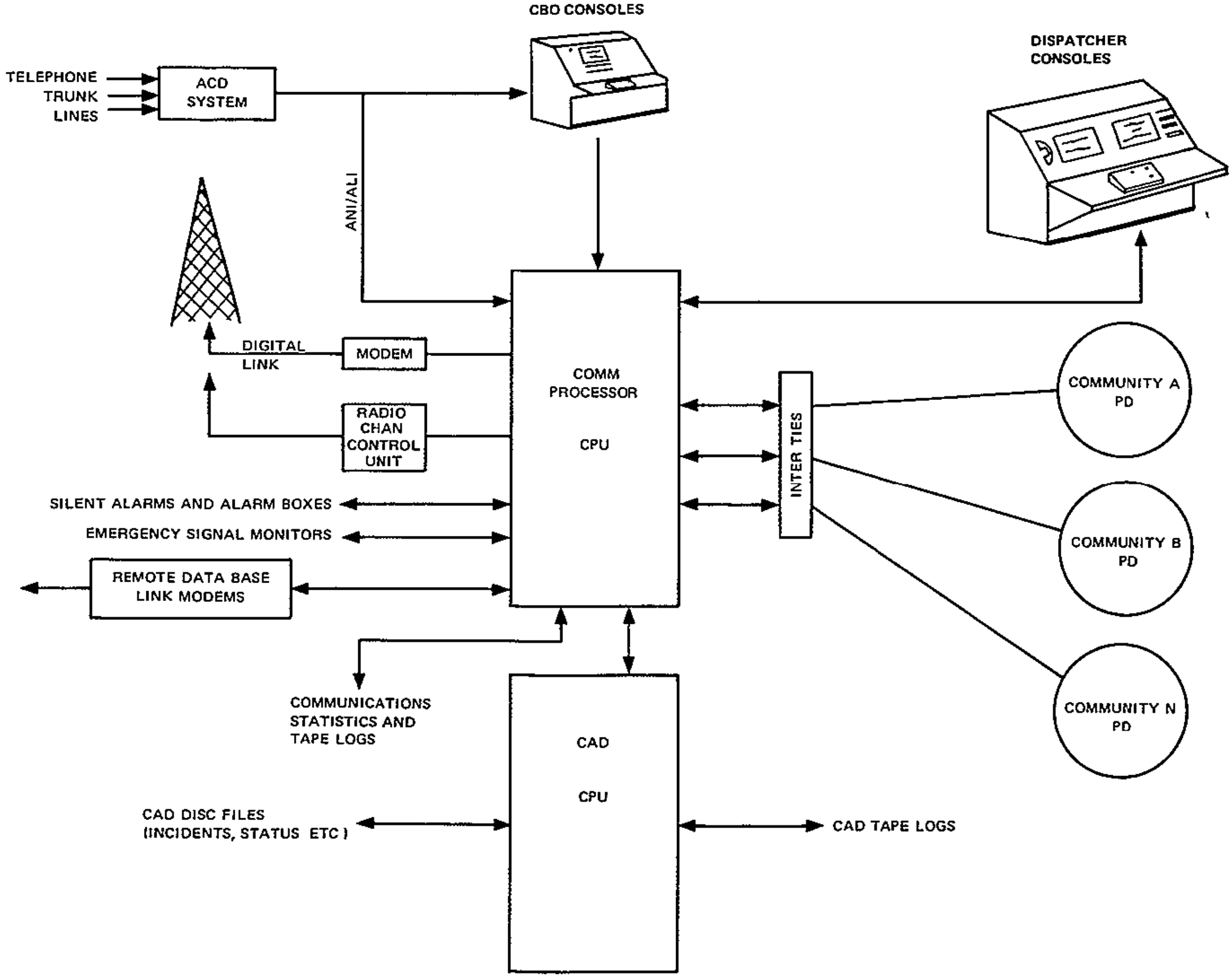


Fig. 15 Digital communications subsystem

Table 9. Functions of the Digital Communications Subsystem (DCS)

Item	Requirements
Channel control	1 Continuously monitor all nondedicated channels for availability, monitor all input lines for messages requesting channel, assign messages to channels to minimize delay
Digital Message Processing	1. Detect and route digital messages from mobile digital terminals to indicated destination (dispatcher, remote data base modems, other)
	2 Route digital messages from dispatcher to addressed MDT
	3 Route digital messages from one MDT directly to one or more others
	4 Route digital messages within the dispatch center
	5. Decode and display or print digital messages as required
ID detection and processing	1. Detect and decode ID preambles on messages from patrol units and route to status files or dispatcher
	2 Detect and decode emergency messages from the emergency network and route to appropriate alarm displays
	3 Detect and decode ID's from silent alarms and alarm boxes and route to appropriate alarm within the dispatch center
	4. Decode ANI/ALI data arriving on telephone lines and display or print as needed
Access Control	1 Provide sign-on/sign-off control for all user terminals
	2 Prevent access to security tables except to designated command personnel with control keys
	3 Provide a data entry point for system file updating from designated control-key entry terminals
Operating Statistics	1. Collect, at designated intervals, statistical data on digital message traffic and channel utilization for transfer to the management data bank
Testing	1. Provide for self-test, interface line/channel and terminal testing on demand from the terminal

In large systems or those with widely separated facilities, the DCS may include a message concentrator multiplexer/demultiplexer that concentrates the digital traffic from a number of local sources for transmission over the link to a remote facility. This technique reduces the required number of tie lines and modems (a modem is a modulator/demodulator needed to put the data on a carrier for transmission over a land line or radio link).

A major reason for the flexibility of digital communications is the simplicity of routing messages. Each message has a short preamble of a few characters that identifies its source and destination (or destinations). The communications processor reads this preamble and then directs the message along the correct path. The preamble is ordinarily added to the message automatically at the source in accordance with the type of message. The routing of messages can therefore easily be changed by changing either the preamble or the protocol (set of directions) within the message processor. No physical changes of wires or plugs are required. It is this flexibility that makes it impossible to intercept and reroute calls at the telephone exchange under emergency conditions, or to have a dispatcher's messages to and from his patrol units easily rerouted to a new console if his regular console fails for some reason.

The quantitative requirements for a digital communications subsystem depend on many factors, including the specific design of the dispatch center equipment, and no general rules of analysis can be given. The example system design given in Chapter 6 will illustrate the procedure, however.

A few of the technical choices that will face the planner in connection with the digital communications subsystem are briefly outlined below.

System Inter-ties. This refers to the interconnection technique used to connect two or more major facilities in a command and control system, where permanent digital links are needed. The links could also be to other agencies. The available techniques are:

- *Direct Point-to-Point.* This is the straightforward procedure, with direct dedicated lines from each facility to the others to be connected with it. These are usually leased lines, and the lease costs can be significant.
- *Multi-drop Points.* With this configuration it is possible to shorten the overall length of the interconnecting lines, provided that the points to be connected are roughly on a line. Where it can be used, it is generally the most economical.
- *Dial-up Acoustical Couplers.* This type of interconnection is suitable only for connections that are not needed on a full-time basis and that handle only low data rates (1200 bps or less). Such couplers are used with standard telephone sets, and consequently can be used to establish links from any point where there is a telephone service (as for a mobile command post).

Circuit Types. Circuits can be of the following types, in order of increasing cost. 1) simplex; 2) half duplex, 3) full duplex. The choice will depend on the nature and volume of communications to be carried over a given link. Simplex means that data can travel in only one direction over the link. Half duplex means that data can go in either direction, but in only one direction at a time. That is, if the line is being used to transmit data from A to B, no data can be transmitted simultaneously from B to A. Full duplex means that data can go in either direction at any time. Data links within a dispatch center are normally full duplex, but interfacility links might be satisfactory with half duplex if the volume of traffic is low.

Modem Types. As noted above, a modem is a device used as the interface between a facility generating or receiving data and the line over which the data is to be transmitted. For low data rate links, the acoustic coupler with a standard telephone set is an adequate modem. For higher data rates it is necessary to have permanently connected modems that synchronize the data for better error control and more efficient transmission. Modem costs increase with data rate, and the planner will need to consider the lease/buy option. For small quantities of modems, the lease/buy crossover point is at about 3 yr (1.5 yr for large quantities, which is another potential saving with combined multijurisdictional systems).

5.6 Display and Control Subsystem

The display and control subsystem is the principal man-machine interface in the command and control system. It consists of the dispatch center consoles, any terminals in other facilities, the mobile digital and voice terminals in patrol units, and all the display and control elements within the dispatch center such as the microfilm display device, printers, slide projectors, plus the manuals and forms used to support the operation.

Since the displays and keyboards of the dispatch center consoles and the mobile digital terminals are used constantly by dispatch center and field personnel, their design is a matter of importance and should be given careful attention. The radiotelephone interface is equally important, but since this type of equipment has been in use for many years its design is fairly well standardized. There are as yet no generally accepted standard designs for CBO, dispatcher, or mobile digital terminal displays and keyboards. Design of displays must reach a compromise between occupying too much display space and taking too long to read or being so cryptic that the operator has to memorize a long list of codes (or has to ask for more data from the computer when it would have been more efficient to present the full data in the first place).

Experience with CAD systems installed to date suggests that for all but the smallest dispatch center loads, human engineering considerations lead to choice of dual CRT displays for dispatcher consoles (one for patrol unit status and the other for incident data and other transient messages). CBO consoles ordinarily need but one CRT.

In the case of mobile digital terminals, there is very limited experience to date on which to base design decisions. Some units have printers, but the trend appears to be toward illuminated alphanumeric displays.

The subject of displays for various operator stations is discussed in detail in the manuals on CAD, MDT and AVL.

5.7 Automatic Vehicle Location (AVL) Systems

The purpose of an Automatic Vehicle Location (AVL) system is to enable the dispatcher to have more accurate information regarding the location of the patrol units under his control. This improved accuracy can help to reduce response time because it increases the probability that the dispatcher will assign the nearest patrol unit to an incident. It also contributes to officer safety in emergency situations, and can be useful where multiple units are to be deployed to meet some special conditions. AVL systems are described in detail in the companion manual on this subject, and will be only briefly covered here. From the planner's point of view, AVL systems are quite costly in relation to the advantages they offer for a small- or medium-size community.

The three basic types of AVL systems are.

Dead Reckoning. In these systems the patrol unit continuously determines its own location by measuring the distance and direction it travels from a known point. This information is transmitted to the dispatch center.

Proximity. These systems use a set of sensors, typically on signposts or light poles, that constitute a network covering the area. They detect the presence of a vehicle and its ID from a beacon carried on the vehicle, and transmit this information to the dispatch center. Alternatively the beacons are on the posts and transmit an ID signal that is picked up by the patrol car and relayed to the dispatch center, indicating that the car has just passed a beacon at a known location.

Radio Location. These are triangulation systems similar to those used for ship and aircraft navigation. They track the location of patrol units by measuring the distance of a unit from three known locations, the measurements are made by transmitting pulses that are returned by the vehicle beacon. A computer then calculates the location from the three distance measurements.

The value of an AVL system will depend on the accuracy with which it determines vehicle location. Accuracy requirements are discussed in detail in the AVL manual, and are summarized below for applications considered in this volume.

- *Dispatch.* The purpose of AVL for dispatch is to reduce response time. This can be achieved if the closest car is dispatched rather than always dispatching the beat car to an incident within the beat. Errors in vehicle location will result in some "wrong" dispatches where the closest car is not sent but some other car which must travel farther. Detailed analyses by several investigators show that a perfect AVL system, i.e., one that always dispatches the closest car, can save 10 to 20 sec in response time compared to no AVL. Further, the savings in response time are not particularly sensitive to AVL system accuracy, that is, a "loose" system saves nearly as much time as a perfect system. For dispatch purposes, an accuracy of 300 to 400 m (980 to 1310 ft) yields nearly all of the potential response time reductions. Larger cities tend to benefit more than smaller cities from AVL-based dispatch systems, and the planner in the smaller community is advised to review the costs and benefits of AVL carefully before recommending its use.
- *Officer Safety.* An accuracy of one-half city block is recommended for this function. With this capability it is expected that a vehicle could be located quickly even in alleys or industrial area mazes.
- *Tactical Control.* To locate units during hot pursuits, blocking of escape routes, or during civil strife or natural disasters requires an accuracy of approximately one city block. This value is somewhat subjective, but seems adequate.
- *Administrative Control.* This function includes reconstruction of past events, public relations, and supervisory functions. For the latter, AVL might be considered an "electronic sergeant" by field personnel. An accuracy of a few city blocks might be adequate for this function, although actual operational experience is lacking in this area. A similar requirement can be stated for analysis of patrol effectiveness.

5.8 Facilities

When an entirely new system is to be put into operation, using a new set of procedures, it is important that the facilities where the new system is located be different from the old, and that they be as pleasant and attractive as possible for the personnel who will be working in them. The change to a new mode of operation is a difficult one in any case, and often meets with resistance. The required psychological readjustment is helped if the new system is associated with a new or remodeled facility, and especially if it is a pleasant place to work.

Ordinarily it is difficult from a technical standpoint to install a new, automated system in an existing dispatch center based on manual dispatching operations. From the logistic as well as the psychological point of view, it is best to install the new system in a new or remodeled facility where it can be set up and checked out, and the operators trained on it, without causing any interference with ongoing dispatching operations. The switchover can then be made with little or no interruption in operations.

The planner should be sure that the plans for new facilities allow for possible expansion in the future if the automated system is to be implemented in stages The initial planning should allow for any additions contemplated in the future.

6. SYSTEM DESIGN

6.1 System Description

Figure 16 is a block diagram of a combined multi-community command and control system that will be analyzed in this chapter. For the sake of clarity, some details have been omitted (card readers, the microfiche files in the CBO and dispatcher consoles, the intercom system within the center, etc.) Features of the system that the diagram is intended to bring out are

- Each police department has full-time, dedicated digital and voice lines connecting it with the central dispatch facility (and through it with all the other police departments).

- There is a console in each police department that has the same connections and capabilities as the dispatcher consoles in the dispatch center. This includes direct access to the computer and thus the capability of monitoring the dispatching activities in the center

- The console in the local police department has access, through a transceiver similar to those in the patrol units, to the central radio transmitter/receiver and consequently to its own patrol units (Provision can easily be made for limiting access by a given police department to the patrol units and files that belong to it.) This means that the person in charge at each police department (normally a sergeant) can, through his console, monitor the activities of his patrol units and assume command of them at any time circumstances require it; he is readily available to monitor and supervise his agency's field personnel as is the case with separate dispatch facilities

- This same capability constitutes a backup mode of operation in case of breakdown of operations in the central dispatch facility.

- Each police department has its own line printer and can cause any relevant data to be printed out in the course of operations (patrol unit activity, data base query "hits," radio and telephone statistics, etc).

- A telecommunications controller handles all external communications except the incoming 911 calls and the 911 calls transferred elsewhere. Dynamic assignment of radio channels is handled in this unit, as well as all required multiplexing/demultiplexing

- All digital messages flow through the digital communications processor. Each message carries a header identifying its source and destination, and the digital communications processor routes the messages in accordance with their destination codes

- The telecommunications controller handles the patching (under dispatcher control) of police department consoles to specified field units.

- All 911 calls come in to the center and are answered by the CBO's, fire and emergency medical calls are transferred to appropriate dispatchers outside the facility. In some cases it is planned to have the fire and emergency medical dispatchers physically located in the same facility with the police dispatching operation, they have not been shown here, but the concept is discussed in Section 2.

- The ANI/ALI data (it is assumed that it will be provided as part of the 911 system) is extracted from the incoming calls by the ACD and sent to the digital communications processor via the telecommunications controller. The digital communications processor then decodes the information and sends it to the CBO console that is answering the call

- Although a dispatch supervisor position is shown, there is no provision for a watch commander or tactical officer. In the case of a multi-community command and control system, the functions normally performed by these positions will have to be worked out by the cooperating communities, there is no "standard" arrangement. Possible arrangements include having one or both of these positions staffed in rotation by officers from the participating departments, or by personnel hired by the jointly-operated entity. It would also be possible to have the desk officers in the individual police departments assume responsibility on the basis of the jurisdiction involved, or on the basis of agreed-upon rules concerning location and/or type of operation needed.

Some of the later discussion in this chapter and in the chapter on implementation planning indicates provisions for

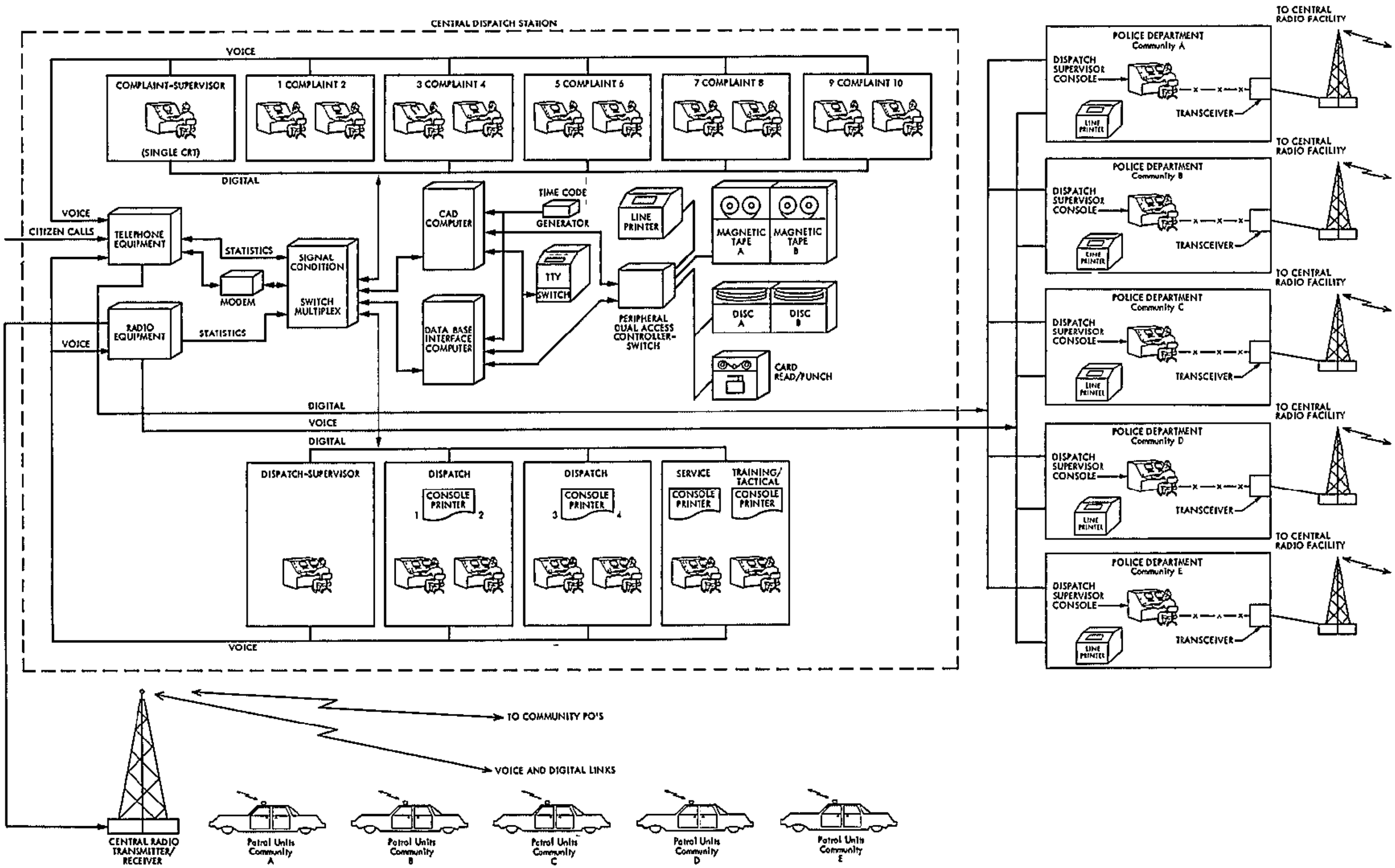


Fig. 16. Multi-community command and control system

an Emergency Command Center function in the dispatch center and for a Mobile Command Post. Neither of these is shown in the diagram, which is intended to reflect only a basic automated command and control system. The required equipment for these two functions is identified and included in the cost estimates of Chapter 7 as of possible interest to planners of new automated control systems for single or multiple jurisdictions. The specific procedures for establishing and activating either an Emergency Command Center or a Mobile Command Post would have to be worked out very carefully in the case of multiple jurisdictions.

Although an Automatic Vehicle Location (AVL) system is indicated on previous diagrams as a part of a fully automated police command and control system, the elements of such a system are not shown on this diagram. The only change that would be required would be the addition of the signpost sensors (if a signpost system were used) or the ranging stations (if a triangulation system were used) The required data processing could be handled in the CAD computer in most cases, or a dedicated AVL minicomputer could be added.[4]

Two extra dispatcher consoles (one dual console) are provided. One is for training purposes and as a spare; the other is for a spare or future expansion Either can be used by a records clerk to enter data in the computer or generate activity reports or other management reports In a fully distributed processing system, a separate processor can be added to handle all management reports. Generation of management reports in a multi-community system is somewhat more complex than in a single system, but a computer can easily be programmed to sort all activity records by jurisdiction (i.e., community) and then prepare the desired reports individually for each community Certain reports (at least telephone and radio channel statistics) will need to be generated for the combined facility as well.

If no dedicated processor is available for generating management reports, it is possible to use the "background" processing mode of the CAD or digital communications or DBQ (Data Base Query) processor to perform this function. Many departments, however, have found it simpler to turn over their tapes containing activity logs to the municipal data processing facility, which then prepares the required reports.

The system considered here does not use a two-level answering arrangement, with a secondary operator to handle longer calls. If it were found desirable to separate calls in this way, not more than one secondary operator position would be required for the system considered here

[4]AVL may not be a high priority capability for many small communities; however, the decision to include AVL must be made on the basis of the specific requirements of each application.

6.2 System Sizing

With the general configuration of the automated command and control system outlined, we can begin to use the procedures discussed in Section 5 to determine some of the quantitative parameters of the system. As a basis for the calculations, we will use the numbers listed in Table 10. From these we find the basic trunk line and personnel requirements to be

Trunk lines	15
CBO positions	12
Dispatcher positions	4

Table 10. Input Parameters for System Design

Parameter	Value
911 busy hour call rate, calls/hr	267
Average call duration, sec	100
Maximum average delay, sec	2.5
911 calls transferred to fire and emergency medical	25%
911 calls transferred to other agencies or requiring no action	45%
911 calls leading to a dispatch	30%
Field-generated calls for service (or self dispatch), calls per shift per unit	4
Direct data base query from field, digital queries per unit per hour	10
Data base query from field, voice queries per unit per hour	2
Data base query responses per query	2 5
Data base query hit responses, percent of queries	15
Field unit status/location updates, per unit per hour	10
Supervisory messages per unit per hour	2
Average peak deployment of field units	100
Area served, square miles	200
City blocks per mile of street	13
Number of communities	5

To these we add one CBO supervisor and one dispatch supervisor position, as shown in Figure 16. One more dual dispatch console is added for training and spares. In each cooperating police department there is one dispatcher console with a line printer; in our example there are five of these consoles (one for each of five communities). The total number of consoles to be procured is thus 13 CBO consoles and 12 dispatcher consoles. There will be slight modifications in the supervisor consoles, as shown in Table 11, Summary of Console Characteristics.

Table 11. Summary of Console Characteristics

Type	Components	Function
Complaint Board Operator Console	Keyboard	Enter incident data to computer
	CRT display (single)	Display format and data as it is entered
	Call director	Accepts calls from public via multitrunk telephone lines and agency's other tie-lines
	Instant playback recorder	Captures incoming call for quick retrieval of information if necessary to confirm or check data
	Microfiche files (one set for two positions)	Maps and other data such as site information, other agency referrals
	Punch clock/ticket tray	Provide for manual taking of complaints if CAD system is not functioning
Complaint Board Supervisor Console	Same as CBO, plus	
	Call director supervision equipment	Monitor incoming call handling
	Telephone activity display	Historical records of telephone activity
Dispatcher Console	Dual CRT display	Display all formats and data
	Keyboard	Enter data to computer
	Instant playback recorder	Capture voice messages for recheck
	Microfiche files (one set for two positions)	Street files and maps, other static reference information
	Radio dispatch panel	Radio communications with patrol units
	Manual equipment	Permits manual dispatch if CAD system is not functioning
	Printer (one for two positions)	Provide printed records as needed
	Call director	Accepts call-box calls from field personnel and other agency communications
	Punch clock/ticket tray	Manual operations
Dispatch Supervisor or Police Department Console	Same as dispatcher console	For communication with other agencies
	Auxiliary radio panel	

The configuration of computer hardware will depend on the basic approach, and could take several different forms. For the case illustrated, we have assumed a distributed processing approach with multiple processors assigned to different functions Table 12 lists the types of computer hardware.

The basis for determining processor size is the transaction rate, which is derived in Table 13. Since every transaction, including those handled by the other processors, must go through the digital communications processor, this unit has the highest throughput requirement. Assuming the following typical times for message handling transactions

I/O Program execution	3.0 msec
2 disc accesses (moving head)	80.0
Core I/O transfer	3.7
High-speed channel message transfer time	38 8
	125.5 msec

and 9000 transactions/hr (which includes a 25% overload for emergency/tactical situations) requiring 4 operations each (2 keyboard messages and 2 screen displays), we have 9000 X 4 X 125.5 = 4,518,000 msec/hr. Since there are only 3,600,000 msec in an hour, there is not enough capacity to handle this peak load The simplest remedy would be to use a fixed-head disc (access time about 10 msec) instead of the moving-head one assumed in the calculations This would reduce the disc accesses from 80 to 20 msec and the total time from 125 5 to 65.5 msec per transaction. We are now using only 2,358,000 msec/hr, which gives ample margin Even with the moving-head disc, the system would have handled the peak load without the allowance for a 25% overload.

In general, there are several processors on the market that would be able to handle the projected digital communications processor load.

The other processors are sized similarly. The Data Base Query (DBQ) machine is the next busiest, with 5,048 transactions/hr. The time per transaction is estimated as·

Program execution (200 instructions)	6.0 msec
One disc access (moving-head)	40.0
Core I/O transfer from DCS machine	8.8
	54 8 msec

Total load is then 5,058 X 54 8 = 276,630 msec/hr, which leaves ample margin

The 3,000 transactions estimated per hour for the CAD machine are estimated to require 136.5 msec each (3 disc accesses are assumed), making only 41,000 msec/hr.

This brief exercise in estimating processor loads indicates that computer throughput should not be a problem in any kind of distributed processing configuration. Even if a single-processor design were chosen, there are minicomputers available at reasonable cost that could handle the projected processing load. Peripheral equipment with the required performance characteristics is also commercially available

6.3 System Software

The software and files for an automated command and control system are described in the companion manual on Computer-Aided Dispatch. For the system considered here, the structure is shown in Table 14. The elements are described in the companion manual and will not be discussed here except in connection with sizing analyses. The items listed that are in addition to those required for any CAD system are those related to the AVL function (which itself is optional).

Core storage modules of 4, 8, and 16K 16-bit words are generally available with minicomputers up to a maximum of 65K words For the busiest processor in the system, 65K words appear to be ample (allowing 32K for operating system and programs in core plus 21K for input and output buffers)

Disc storage requirements are estimated from Table 15, which lists the programs and files that would normally be kept on disc files. The size of each record in a given file is estimated in Table 16, these estimates were used to derive the total file sizes listed in Table 15. From Table 15 we can define the following requirements for disc storage units

Digital communications	1 megabyte fixed head (two units)
Computer-aided dispatch (plus AVL, if used)	25 megabyte moving head
Data base query	25 megabyte moving head
Management Reporting	25 megabyte moving head
System spare	25 megabyte moving head

The four 25-megabyte units are oversized for the last three applications, but the extra capacity costs relatively little and is available to support a degraded mode of operation for the CAD system if the CAD disc unit should fail.

Table 12. Summary of Computer Hardware

Item	Description and Function
Processors	Each consists of a central processing unit (CPU), memory (usually magnetic cores) and input/output logic The memory stores program instructions and data; the CPU executes the instructions, using the stored data, the I/O logic interfaces the processor with the input devices (the console keyboards, the disk and tape units) and the output devices (the console displays, the disc and tape units, printers) to move data into and out of the processor.
Disc Storage Units	There are one or more disc units in the system, depending on the size of the files to be stored Ordinarily a single disc pack with a capacity of several million bytes is large enough to store all the programs and data for a CAD system Disc storage provides a rapid means of accessing a large quantity of data or instructions, those programs and files that are not maintained in the processor's core memory are stored in the disc unit, where they can be brought into core as needed in a matter of milliseconds. Duplicate disc units with duplicate data are sometimes maintained to protect against accidental data loss or disc system failure
Magnetic Tape Units	Tapes are normally used for permanent storage of data, and the amount of data that can be stored in this way is virtually unlimited Tapes are usually easily transferred from one facility to another if they are needed for historical or statistical studies
Card Reader	The normal method of entering programs into the computer for initial development and checkout is through punched cards A 300-card-per-min reader should be adequate for a CAD system
Line Printer	Any printed output from the system that has significant volume, such as activity logs and all types of management reports, requires the speed of a line printer. The printer would normally be associated with the records clerk position It need not be a very high-speed printer, but should be faster than a teletypewriter
Console Teletypewriter	A teletypewriter is provided for each pair of dispatcher positions (one per dual console) This fairly low speed printer is adequate for generating the small amount of hard copy needed from the consoles
Modems	A modem (modulator/demodulator) is needed for each interface of the system with other digital systems, primarily for purposes of remote data base query (DMV, NCIC, etc) A modem allows a computer to communicate with another computer over standard telephone lines A modem is also needed in systems where the patrol units are equipped with digital terminals that can communicate directly with the computer or with remote data bases The system modems are part of the facility's interface signal conditioning assembly
Time Code Generator	A time code generator unit is provided at the dispatcher and mobile command centers for the purpose of providing serial time code signals to the voice log recorders and date-time to the system processor as needed for event/transaction synchronization
Tape Search Unit	A tape search unit capable of reading the serial time-code data recorded in the voice log tapes This unit allows search and playback of a portion of the log tape starting at a selected date-time period set at the unit
Voice Log Recorders	At the dispatch facility the telephone and radio voice signals are recorded on a 24 tape recording unit The units include as many recording channels as there are facility work positions with voice transaction capabilities An additional recording channel is provided for date-time serial code recording A similar unit typically is provided for off-line playback of log tapes.
Automatic Call Distributor	The dispatch facility includes an automatic call distributor (ACD) as part of the telephone equipment set, capable of load balancing among the CBO positions It will decode the ANI/ALI data for CAD processing, collect live statistics and issue an alert call overload signal to all CBO and supervisory positions

Table 13. Transaction Rates

Transaction	Factor	Per = No. Per Hr.		Source	Destination	Remarks
ANI/ALI Message	1	Call	267	Tel Co	CBO	
Calls transferred to fire/EMS	0 25	Call	67	CBO	Fire/EMS	
Calls transferred elsewhere	0 45	Call	120	CBO	Other agency	
Calls processed for dispatch	0 30	Call	80	CBO	Dispatcher	
Field generated calls for service	0 5	Unit/hr	50	Car	Dispatcher	
Dispatch orders assigned	1	Dispatch	130	Dispatcher	Car	
Dispatch orders completed	1	Dispatch	130	Car	Dispatcher	
Car status/location updates	10	Unit/hr	1000	Car	Dispatcher	AVL or other
Car-to-car messages	2	Unit/hr	200	Car	Car	Voice or digital
Car supervisory message request	2	Unit/hr	200	Car superv.	CAD	
Car supervisory messages	1	Request	200	CAD	Car superv	
Car data base query (voice)	2	Unit/hr	20	Car	Dispatcher	10 units only
Dispatcher DBQ for above	1	Query	20	Dispatcher	Data Base	
DBQ response to dispatcher	2 5	Query	50	Data Base	Dispatcher	
Dispatcher response relay to car	1	Query	20	Dispatcher	Car	
Car direct digital to DBQ	10	Unit/hr	900	Car	Data Base	90 units
DBQ response to car	2 5	Query	2250	Data Base	Car	
DBQ hit response	0 15	Query	138	Data Base	Dispatcher	920 queries total
DBQ digital hit response to car	0.15	Query	135	Data Base	Car	900 queries
Warrant abstract request	1	Hit response	138	Car	Data Base	

Table 13 Transaction Rates (contd)

Transaction	Factor	Per = No. Per Hr.		Source	Destination	Remarks
Warrant abstract	1	Request	138	Data Base	Car	
Deployment schedule and updates	2	Dept /hr	10	Local Dept	Dispatch Ctr.	
Car sign-on/sign-off	2	Unit/shift	200	Car	Dispatcher	
Work station sign-on/ sign-off	46	Shift	46	Work station	CAD	Local depts plus dispatch center
Work station and car activity log	123	Shift	123	Work station	CAD	Local depts plus dispatch center
Printout of dispatcher log	6	Disp/hr	24	Dispatcher	Printer	For manual backup
Printout of DBQ hit responses	1	Hit	138	Data base	Printer	For manual backup
Management records	5	Hour	30	CAD	Printer	
Statistical reports	1	Source	6	Source	CAD	6 sources
Transaction log transfers	12	Hour	12	CAD	Tape logs	For analysis and reporting

Table 14. Software and File Structure for a C&C System

Operating System	User Programs	Data Files: Real-Time Files	Data Files: Permanent Files
*System Generation	*Facility Digital Communications Control	*Access Authorization	Display/Comms Formats
*Job Scheduler	*Sign-on/Sign-off	*Incident File	Address Verification
*Communications Control	Telephone ANI/ALI Decoding	*Incident Summary File	Telephone Directory
*Executive Services	*Incident Log-in	*Patrol Unit Status File	Address/Area Intelligence File
*System Recovery	*Dispatch Log-in	*Deployment Schedule	ECC/MCC Resources File
	*Emergency/Microphone Identification Decoding	Temporary Situation	AVL Sign Post Identification Table/File
	*Patrol Unit Status	Radio-telephone Digital-Data Base Query Statistics	AVL Map Graphics Overlay Coordinate Data Points
	Patrol Unit Location AVL	Operator Activity File	
	*Data Logging	Patrol Unit Activity File	
	Data Base Query		
	Management Reports		
	Deployment Schedule		
	ECC/MCC Tactical/Intelligence Planning		
	AVL Location Graphics		
	Case Reconstruction Playback		

*Basic elements, remaining elements are optional

Table 15. Disc Storage Estimates (1000 bytes)

1. Digital Communications	
Core image program	64
I/O buffer (5 min at 1000 char./I/O message)	750
Message I/O format skeletons (33 formats)*	7
Daily schedule access authorization	39
Total	860

2 CAD/AVL	
Core image programs	64
I/O buffer (5 min at 1000 char./I/O message)	200
Message I/O format skeletons (10 formats)	2
Master street file	12,844
Street index	7,977
Land mark	190
Telephone directory	12
Address intelligence	49
Temporary situation	18
Deployment schedule	57
Incident log (2 hr)	169
Incident summary (2 hr)	16
Unit status	35
AVL sign post table (at 169 post/mi 2)	3,211
AVL graphic overlay (200 overlays)	120
Total	24,964

*Commonly used formats such as incident log-in, unit status, data base query, license plate, stolen vehicle, etc

3 DBQ	
Core image programs	64
I/O buffer (5 min at 1000 char /I/O message)	420
Message I/O formats (20 formats)	4
Schedule/access authorization	39
ECC/MCC support	50
Total	577

4. Management Reporting	
Core image programs	64
I/O buffer (5 min at 1000 char /I/O message)	47
Message I/O formats (40 formats)	8
Deployment schedule	57
System access authorization	39
Incident log (10 hr)	845
Incident summary (10 hr)	82
Unit status/locations	35
Unit activity	186
Operator activity	23
Communications statistics (24 hr)	10
ECC/MCC support programs	32
ECC/MCC resources (1000 entries)	137
Operating system (DCS, DBQ, CAD/AVM Support)	128
Total	1,693

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Table 16 Record Sizes of Data Files

File Name	Record Size (characters)
Real Time Files	
Access Authorization	85 (per person)
Incident File	650 (per incident)
Incident Summary File	63 (per incident)
Patrol Unit Status File	178 (per field unit)
Radio-telephone statistics	196 (per hour)
Operator Activity File	563 (per operator per shift)
Patrol Unit Activity File	928 (per unit per shift)
Deployment Schedule	124 (per person)
Temporary Situation (Short term intelligence)	175 (per address/area)
Log Tape Reel Index/Storage File	85 (per reel)
Permanent Files	
Display/Comms Skeleton Formats	200 (per display format)
Address Verification	
Street index	236 (per street name)
Landmark file	95 (per landmark)
Master street file	92 (per block face)
Telephone Directory	
Emergency telephones	80 (per telephone)
Foreign language translation assistance	80 (per telephone)
Nonemergency telephones	80 (per telephone)
Address Intelligence File (Long-term intelligence)	245 (per address/area)
AVL Sign Post Identification Table	95 (per sign post)
AVL Map Overlay Coordinate Data Points	600 (equivalent characters per display overlay average)
ECC/MCC Resources	137 (per item entry)

7. IMPLEMENTATION PLAN

An implementation plan is an essential element in the design and evaluation of a new automated command and control system that is being considered. It is part of the planning process, rather than a document that is needed only when the decision has been made to proceed and the system designed.

The reason an implementation plan is a part of the planning process is that it is the only effective means of identifying all the things that will have to be done to bring a new system into operation. It is easy to obtain estimates from contractors for the design and physical installation of the new system, but there are additional costs, as well as additional tasks that must be taken into account and provided for. Where different system configurations are being considered, preparing an implementation plan for each of them is a good method for comparing total costs vs performance.

In the case of a combined multi-community police command and control system, the implementation plan requires particular care because of the large number of interfaces (electronic, procedural, legal, administrative) that must be defined carefully and agreed upon if the system is to function satisfactorily to all parties.

The two principal parts of an implementation plan are the schedule and the funding plan. The schedule should indicate start and end dates for at least the following major activities (with subactivities in most cases)

(1) Precontract phase

(2) Procurement of the system

(3) Facility preparation

(4) Installation and checkout

(5) Demonstration and acceptance

(6) Personnel training

(7) Maintenance

The precontract phase should include schedules for the necessary agreements with other local agencies and with the telephone company (for 911 service) and for defining the interfaces with remote data bases to be accessed In the case of a combined multi-community system, ample time should be allowed for negotiating the details of the Joint Powers Agreement or other legal instrument creating the cooperative operation.

It is often desirable because of funding constraints to plan for a phased implementation, such as will be illustrated later in this chapter. The schedule should certainly reflect the phasing plan, defining clearly what items are to be implemented under each phase.

The funding plan portion of the implementation plan should show complete cost estimates for all items of expense, and should include a breakdown of expenditures by fiscal year from the start of funding to completion of the system implementation This could be a period of 5 to 10 years in the case of a phased implementation. The funding plan should also estimate the continuing maintenance costs for the system. The general categories of expense that should be included in the funding plan are·

(1) The program management office to be set up by the local agency (or jurisdictions) to manage the entire project

(2) Any consulting or systems engineering support that is planned (in addition to the work of the prime system contractor)

(3) Procurement of equipment and software, including design and engineering effort included in the procurement package

(4) Facilities acquisition and preparation

(5) Logistics, particularly training. As noted above, continuing maintenance should also be estimated.

The remainder of this chapter presents an example of an implementation plan, based on the system described in Chapter 6. The plan reflects a phased procurement divided into four phases, each adding an increment of capability to the preceding phase. The items associated with each phase are listed in Table 17. The capabilities available in each phase are summarized as follows

Phase I This is the most important and largest change to the existing system. It provides for the basic CAD functions – keyboard/CRT entry and manipulation of data by CBO and dispatcher, automated record keeping, computer-maintained patrol unit status files, and other basic functions The mode of operation can become a degraded mode in the event of failures after the full system is implemented CAD should be considered the backbone capability, to which other functions such as digital communications and AVL can be added.

Table 17. Procurement Activities by Phase

Phase	Activities
I — Basic automated capability	1. Prepared new facility (including air conditioning, standby power, telephone connections, etc.)
	2. Install CBO and dispatcher consoles
	3. Install police department consoles
	4 Install data processing computer (dual units for redundancy)
	5 Install software and check out system
	6 Train personnel
II — Augmented capability	1. Install two additional processors — digital communications switchers and management reporting
	2 Install new fixed and mobile radio equipment
	3 Install and check out software for added CAD capabilities and management reports
	4. Train personnel in added capabilities
III — Full capability less AVL	1 Install Data Base Query (DBQ) processor
	2 Install DBQ software in DBQ processor
	3 Install digital communications modules in mobile radio
	4 Add mobile digital communications software to dispatch center processors (primarily direct digital status updates and acknowledgements
IV — Add AVL capability	1 Install AVL "signpost" sensors in area served
	2. Modify mobile digital terminals as needed
	3 Add software in CAD processor to handle AVL data

Phase II. In this phase, the full CAD capability becomes available, with automated formatting and checking of complaint and incident records, maintenance of incident backlog files, recall of incidents in progress to add or modify data, and the full range of management reports generated by computer System reliability is increased by the availability of the added processors as standbys for others if necessary.

Phase III Capability is significantly increased in this phase by the addition of mobile digital communications This reduces radio channel-crowding and permits direct status updates via the computer, reducing the load on the dispatcher The equipment for automated Data Base Query is also added, so that the patrol units can query remote data bases directly without involving an operator or dispatcher in the dispatch center.

Phase IV. The only change in this phase is the addition of Automatic Vehicle Location (AVL) capability by the installation of AVL signposts throughout the area and appropriate modification of the mobile terminal and dispatch center software. The computer-maintained patrol unit status files now show vehicle location as well as status Provision can be made in the CAD software to have the computer automatically determine the location of the nearest one or more units to the location of a given incident and present this information to the dispatcher

Cost estimates for the sample system are shown in Tables 18 through 23. Table 18 lists the cost estimates by category in each phase The totals shown here are derived from the more detailed tables indicated for each category. Table 19 shows the estimated cost of maintaining the law enforcement agency program office during the full implementation period. Table 20 lists the manpower costs estimated by a contractor undertaking a turn-key contract for such a command and control system, note that such costs are typically negotiable and are affected by the current state of competition in the industry The current catalog prices of the kinds of equipment needed for the dispatch center are listed in Table 21. Table 22 lists separately the cost estimates for equipping a local police department with the type of console that would be needed to interface with the system (the same would be needed for any other command center remote from the central dispatching facility) The item in Table 18 listed as "local department equipment" assumes five such local departments, as shown in Figure 16. The costs of the radio equipment, both fixed and mobile and for voice and digital traffic are listed in Table 23. The estimates in Table 18 assume that new equipment is procured if a system does not need entirely new equipment, the costs could be revised accordingly Table 23 also assumes procurement of a microwave system to link the parts of the system, but this item too is not necessarily a part of a new command and control system Such links may already be in existence, or leased lines may be felt adequate The procurement of microwave links should be examined, however, since the cost can often be recovered in a few years from the saving on lease costs

Table 18 Total System Implementation Cost Estimate
(thousands of dollars)

System Phase Implementation	Pre-Procurement	Phase I	Phase II	Phase III	Phase IV	Total
Program Management (Table 19)	134	137	103	100	68	542
Prime Contractor (Table 20)	–	882	705	554	440	2,581
Facilities Preparation Update	10	100	20	–	–	130
Dispatch Center Equipment (Table 21)	–	987	410	133	22	1,552
Local Department Equipment (Table 22)	–	115	–	–	–	115
Fixed Radio Sites (Table 23 less field units)	–	–	289	69	–	358
Field Unit Voice Radio (Table 23)	–	–	660	–	–	660
Field Unit Digital Terminals (Table 23)	–	–	–	1,050	–	1,050
AVL Sign Post (Table 23)	–	–	–	–	500	500
TOTAL	144	2,221	2,187	1,906	1,030	7,488

The cost estimates given here are provided as guidance to planning personnel considering the procurement of a new command and control system The only way to obtain a reliable estimate of the cost of a particular system is to define a system configuration, obtain estimates from contractors, and prepare an implementation plan. Also, certain items of expense have not been included in the estimates because of the wide range of possible variation depending on the local conditions. These include.

- Telephone equipment and leased lines additional to those already in use
- Relocation or replacement of office equipment
- Supplies additional to those now used (tape reels, printer paper and ribbons, spare disc packs. etc.)
- Personnel costs resulting from developing new data files, training scenarios, and training materials, etc.

Small police departments planning to join together in a combined multijurisdictional system will want to be particularly careful in their planning and cost estimating, since there may be requirements and items of cost associated with this mode of operation that are not mentioned in the above estimates and not encountered by single-jurisdiction systems Cost sharing arrangements will also have to be worked out with care.

There is so little experience with arrangements of this type that there is no extensive body of data or knowledge to serve as a basis for planning It is likely that there will be increasing numbers of such joint systems in the future, however, and planners should make an effort to keep up with all such developments.

A typical top-level schedule, listing only the major categories of activity, is shown as Figure 17. It reflects the phased procurement discussed earlier and is intended to suggest the lengths of time that are typically required for the types of activity listed

Table 19. Law Enforcement Agency Program Office Cost Estimate

System Phase	Pre-Procurement		Phase I		Phase II		Phase III		Phase IV		Total	
Schedule/Cost	Man Months	$	Man Months	$	Man Months	$	Man Months	$	Man Months	$	Man Months	$
Senior Officer $2,000/mo	11	22,000	12	24,000	9	18,000	9	18,000	6	12,000	47	84,000
Police Officer $1,400/mo	11	15,400	12	16,800	9	12,600	9	12,600	6	8,400	47	65,500
Administrative Analyst $1,600/mo	6	9,600	6	9,600	5	8,000	4	6,400	3	4,800	24	78,400
Communication Eng $1,800/mo	11	19,800	12	21,600	9	16,200	9	16,200	6	10,800	47	84,600
Data Processing Eng $1,800/mo	11	19,800	12	21,600	9	16,200	9	16,200	6	10,800	47	84,600
Clerk Typist $750/mo	11	8,250	12	9,000	9	6,750	9	6,750	6	4,500	47	35,250
Total Schedule/Cost	61	94,850	66	102,600	50	77,750	49	76,150	33	51,300	–	402,650
Employee Benefits at 30%	–	28,455	–	30,780	–	23,325	–	22,845	–	15,390	–	120,800
Total Personnel Cost	–	123,305	–	133,380	–	101,075	–	98,995	–	66,690	–	523,445
Office Equipment and Supplies	–	7,500	–	500	–	500	–	500	–	500	–	9,500
Travel	–	3,000	–	3,000	–	1,000	–	1,000	–	500	–	8,500
PROGRAM MANAGEMENT COST	–	133,805	–	136,880	–	102,575	–	100,495	–	67,690	–	541,445

Table 20 System Contractor Cost Estimates

System Phase	Phase I		Phase II		Phase III		Phase IV		Phase V‡		Total	
Schedule/Cost	Man Months	$	Man Months	$	Man Months	$	Man Months	$	Man Months	$	Man Months	$
Hardware development	45	157,500	20	70,000	17	59,500	15	52,500	27	94,500	124	434,000
Software development	70	245,000	45	157,500	30	105,000	35	122,500	40	140,000	220	770,000
Documentation/ Miscellaneous	15	52,500	5	17,500	3	10,500	5	17,500	10	35,000	38	133,000
Procurement handling*	—	98,700	—	145,100	—	125,200	—	65,300	—	78,400	—	512,700
Acceptance Test	2	7,000	2	7,000	2	7,000	2	7,000	2	7,000	10	35,000
Training and Phaseover	3	10,500	3	10,500	2	7,000	3	10,500	3	10,500	14	49,000
Program Management**	—	114,240	—	81,520	—	62,840	—	55,060	—	73,080	—	386,740
Equipment Maintenance***	—	7,100	—	5,200	—	3,000	—	500	—	2,000	—	17,800
Travel and Subsistence	—	20,000	—	15,000	—	10,000	—	10,000	—	20,000	—	75,000
Fixed Fee — 10% of Cost	—	169,954	—	196,032	—	164,204	—	99,386	—	124,448	—	754,024
Total Contracted Cost (less Eq)	—	882,494	—	705,352	—	554,244	—	440,246	—	584,928	—	3,167,264

Notes Average man-month cost 3,500$/MM

Fixed Fee 10% of contractor cost including equipment cost.

*10% of equipment cost

**20% of contractor's direct labor cost

***Original equipment manufacturer monthly maintenance cost during test at contractor

‡Emergency Command and Control/Mobile Command and Control development and implementation phase

Table 21. Central Dispatch Facilities Equipment Cost Estimate

Item	Function	Qty.	Unit Cost, 1000$	Total Cost, 1000$	Total Monthly Maintenance, $
1) Minicomputer with 16K words of core and std options (power fail, real time clock, interrupts, etc)	2 — each digital comms 1 — CAD/AVL 1 — Data base query/ECC-MCC 1 — Management report/ECC-MCC	5	20.0	100.0	850
2) 16K word memory add-on modules	Memory add-on modules Three each per processor	15	6 5	97 5	487
3) Direct memory access 4-channel assembly	One assembly each per processor	5	8 0	40.0	200
4) Memory protect assembly	One assembly per processor	5	1 0	5 0	50
5) Interrupt expansion assembly	One each per processor	5	1 5	7 5	40
6) Dual access/megabyte fixhead disc controller and servo	Digital communications processor One plus one backup disc unit	2	19 0	38.0	266
7) Dual access 25-megabyte moving head disc controller with 2 servos	One assembly with 2 disc servos for CAD/AVL DBQ/ECC-MCC and Mgmt/ECC-MCC	3	41 0	123 0	825
8) TTY with paper tape read/punch	Processor maintenance and backup	2	6 0	12 0	136
9) Card punch (100 CPM)	Program development file update	1	30 0	30 0	162
10) Card reader (300 CPM)	Program load/File update	1	4 0	4 0	24
11) Line printer (600 LPM)	Reports printing and software development	1	18 0	18 0	125
12) Magnetic tape units and dual access controller (75 IPS — 800/1600 BPI — 9TRK)	Tape logging 1 — Recording 1 — Stand-by 1 — Play-back/ECC-MCC	3	19.0	57.0	630
13) Time code generator	Serial/parallel day of year and time of day	2	3.5	7 0	50
14) Command console — printer	Dispatch center consoles — ECC consoles	10	1 5	15 0	100
15) Console instant playback — voice	Operator voice transaction record, instant playback	31	0 6	18 6	310
16) CRT/KB terminal	"Smart" terminal for all consoles	31	4 5	139 5	800
17) CRT monitor (for dual CRT consoles)	Dispatch center consoles — ECC consoles	10	2 5	25 0	150

Table 21. Central Dispatch Facilities Equipment Cost Estimate (contd)

	Item	Function	Qty.	Unit Cost, 1000$	Total Cost, 1000$	Total Monthly Maintenance, $
18)	Radio channel select and monitor assembly	Facility radio control channel monitor, emergency/mike IO decoding and console controls	1	200.0	200.0	1,200
19)	Signal conditioning and processor peripheral multi-access assembly	Interface all processors to selected peripherals (disc-tape print, etc.)	1	200.0	200.0	850
20)	Communications signal conditioning voice/digital lines assembly	Multichannel high-speed line communications interface and buffer multiplexer	1	100.0	100.0	400
21)	Telephone automatic call director and monitor	Facility telephone-console interface and controls Call-director Voice-digital line Traffic monitor	1	200.0	200.0	850
22)	High speed data modems, 2.4 KB	ACC-MCC-data base radio digital line communications	10	1.5	15.0	50
23)	Microfiche viewers	One per two operator work positions	12	2.5	52.5	480
24)	Uninterruptible power system	Power backup, 15 kW	1	45.0	45.0	1,200
25)	Facility cabling and work position cabinet/assembly	Cabling of total system at facilities and cabinet assembly	1 (Lot)	30.0	30.0	—
26)	AVL graphic terminal	AVL field deployment location — dispatch center and ECC	4	6.0	24.0	250
27)	Voice magnetic tape recorder/playback (24 hr)	Tel/radio/operator voice transaction log	5	15.0	75.0	250
28)	Tape search unit	Playback tape search and time input	1	4.0	4.0	10
		TOTAL COST			1,682.6*	10,735

Note a) Console Equipment Items 14, 15, 16 and part of 18 and 21 are integrated into console/work position chassis assembly

b) Items 18, 19, 20, 21 and 25 are custom-designed equipment.

*Includes cost of Phase V equipment items (see note on Table 20).

Table 22. Local Police Department Console Cost Estimate

Item	Function	Qty	Unit Cost, 1000$	Total Cost, 1000$	Total Monthly Maintenance, $
1) CRT/KB Terminal	"Smart" terminal	1	4 5	4 5	30
2) CRT Monitor	Second CRT for work position	1	2 5	2 5	15
3) Console Printer	Recovery print	1	1 5	1 5	10
4) Console Instant Record/Playback	Operator voice transaction instant playback	1	0 6	0 6	10
5) Line Printer (150 LPM)	Reports and daily field unit activity record	1	7 0	7.0	100
6) High Speed Data Modern 2 4 KB	Interface to dispatch center facility and backup	2	1 5	3 0	10
7) Radio Control Console Assembly	Operator/Field voice — Emergency/Mike ID decoding	1	2 0	2 0	10
8) Telephone Call Director Console Assembly	Telephone Tie-line PBX	1	1 0	1 0	10
9) Miscellaneous Cabling and Cabinet Assembly	Console/work position integrated set	1	1 0	1 0	—
TOTAL COST PER DEPARTMENT				23 1	185

Table 23. Field Radio Communications Cost Estimate

Item	Function	Qty.	Unit Cost, 1000$	Total Cost, 1000$	Total Monthly Maintenance Cost, $
1) Radio Transmit Receiver Monitor Main Base	Fixed Site Radio Transmit/ Receiver-Voter Equipment Voice-Digital	1 (Lot)	174 0	174 0	1,200
2) Radio Transmit Receiver-Monitor Auxiliary Bases	Radio Monitor and Voter Equipment Voice-Digital	1 (Lot)	50 0	50 0	500
3) Microwave Network	36-channel Microwave Net (All Facilities/MCC)	1	124 0	124 0	1,000
4) Uninterruptible Power System	Backup power 25 kW Main Radio Base	1	10 0	10 0	500
5) Mobile/Portable Voice Transceiver	Field Unit Mobile/Portable Voice Transceiver with Emergency and Mike ID code and channel control	300	2 2	660 0	1,500
6) Mobile/Portable Digital Communication Terminal	Field Unit Mobile/Portable Digital Communication	300	3 5	1,050 0	1,500
7) AVL Sign Post Transmitters	Sign Post for approximately 1/3 of the city street cross point intersections	10,000	0 05	500 0	1,500
TOTAL COST				2,568 0*	7,700

Note a) Items 1, 2, 3, 7 are custom designed for the given area coverage

b) Items 6 and 7 are engineering estimates for large quantity production

*Includes cost of Phase V equipment items (see note on Table 20)

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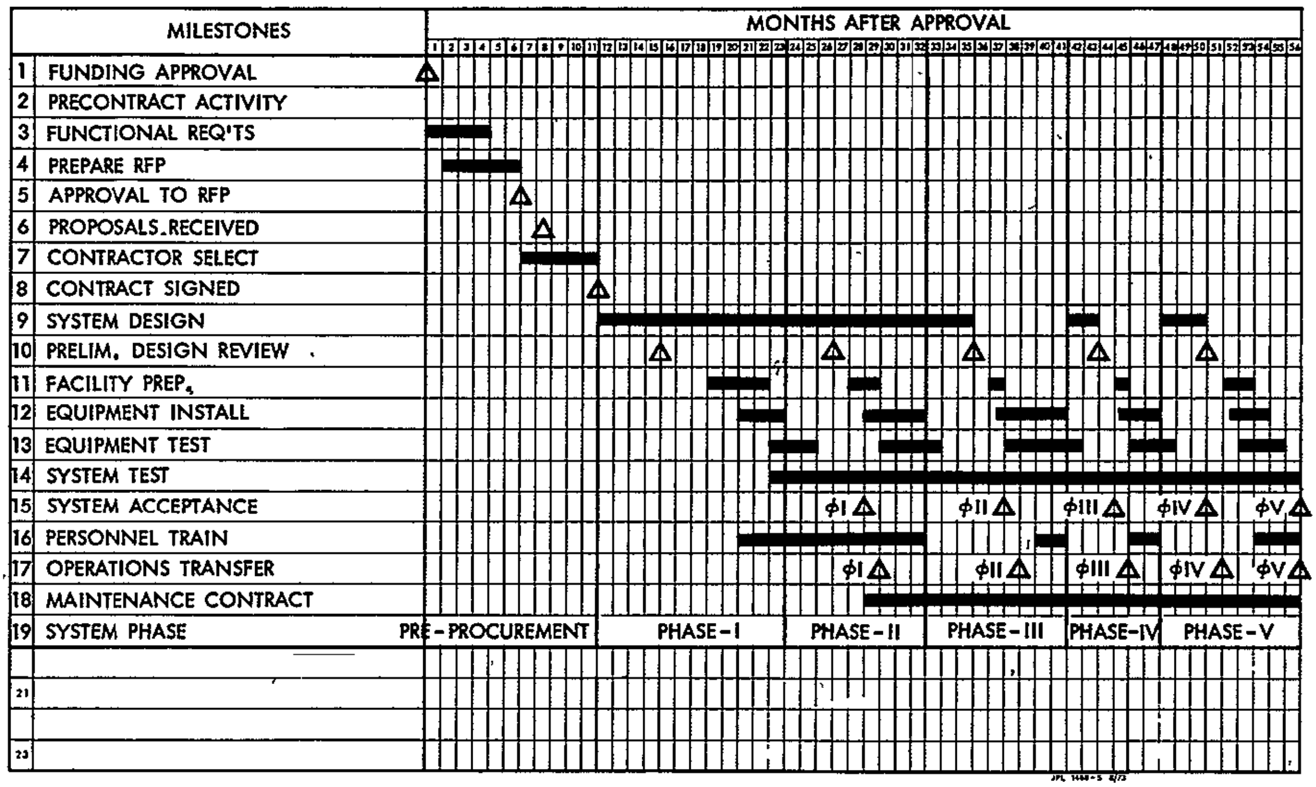

Figure 17. Overall Schedule of Activities

8. COSTS AND BENEFITS

Cost vs benefit analyses of CAD systems, digital communications systems, and AVL systems are presented in the companion manuals on those subjects. This section will examine the costs and benefits associated with the implementation of a multi-community police command and control system, on the assumption that the individual police departments are not at present using advanced technologies such as CAD, MDC, and AVL.

It is important for planners in small-to-medium jurisdictions (up to half a million population) that are adjacent to other small-to-medium jurisdictions to give serious consideration to preparing a joint plan with their neighboring departments for a cooperative, computer-aided command and control system including several departments. The advantages are significant·

- Federal funds to subsidize upgrading of local police command and control systems are usually easier to obtain for such joint or cooperative systems. It may be difficult for a small department to obtain such funds an an individual applicant.
- Radio channel crowding is especially troublesome in the case of several adjacent but separate radio dispatch systems A combined computer-aided system helps relieve this congestion in two ways: 1) all the channels of the departments can be managed as a common resource, resulting in efficient allocation of this resource, and 2) converting a large portion of the message traffic to digital form reduces the channel congestion significantly for the same volume of messages
- Service to the public can be improved, as will be discussed below.
- Very significant savings can be made in operating costs, most particularly in personnel costs.
- Savings in procurement of both capital equipment and operating supplies can be effected because of the larger scale of purchases by a combined operation

Aside from these important benefits, there is the advent of the 911 emergency calling system to be considered Operation of 911 system will be more complex and more costly when it has to deal with a large number of small jurisdictions, and in some areas legislation will require the 911 answering and dispatching function to be taken over by a larger jurisdiction such as a county if there are no regional cooperative arrangements.

As an example of a particular case of a combined multi-community police command and control system using the latest technology, this section will present some of the data on the system that is now in the process of being implemented by a consortium of several adjacent cities. This chapter will emphasize the cost-benefit aspects of the planned system

The analysis that served as the basis for planning of the system considered three alternatives for the new system.

Alternative A. Upgrade all ten dispatch facilities, but leave them separate

Alternative B. Combine all dispatching for the ten cities in a single, central automated dispatch facility

Alternative C. Combine all dispatching for the ten cities in two automated dispatch facilities

The starting point for the analysis was the present configuration of the various police departments concerned, as shown in Table 24 Table 25 lists the estimated costs of one of the alternatives (B), as an indication of the kinds of changes that would have to be made and their costs. Similar tabulations were made for all the other alternatives; the results are summarized in Table 26.

It should be noted that the figures given in the comparative tables, although based on the best data available, provide only rough indications of predicted costs. For example, no allowance has been made in the predictions for increase of personnel costs over the 5-yr period from 1975 to 1979. Since one of the major cost benefits of a combined and automated system of command and control results from a reduction in personnel requirements, realistic allowance for such increases would make the differences even greater. The relative decrease in personnel costs is accompanied naturally by an increased percentage (10% rather than less than 5%) devoted to equipment costs; over the last few years, however, equipment costs for both leased and purchased items have increased at a much slower rate than personnel costs

The estimates of personnel costs are based on the following approximate salaries.

Dispatchers	$10,000 per annum
First-level supervisors	17,000
Second-level supervisors	20,000

Table 24 Characteristics of Present Departments

City	1	2	3	4	5	6	7	8	9	10	Total
Population	38,500	16,000	47,183	55,500	19,200	93,285	35,352	14,350	63,649	140,000	523,019
Area, Mi^2	4 84	5 46	5 21	5.58	1 3	8 85	3.8	4.75	6 028	20 49	66 30
Sworn Officers	60	59	73	57	32	155	52	21	67	194	770
Civilian Staff	21	18	20	12	13	58	11	2	54	56	265
Police Vehicles – Radio Equipped	28	23	19	25	24	73	20	7	27(1)	87	333
Portable Radios	22	15	6	12	10	30	8	5	4(2)	18	130
Part I Crimes (1972)	2,607	1,114	2,165	1,829	1,000	7,179	1,435	479	4,614	8,019	30,441
Calls for Service (1972)	7,153	21,736	26,419	33,377	14,260	12,600(3)	5,012	18,584	37,922	87,059	264,122
Communications Staff	5	5	5	1 + 6(4)	4	19	5	2(4)	13	7 + 12(4)	84
Logging Tape Recorder	YES	NO	YES	YES	NO	YES	NO	NO	YES	YES	–
Use Dispatch Cards	NO	YES	NO	NO	YES	YES	NO	NO	YES	YES	–

(1) Also have 25 VHF mobiles in same vehicle
(2) UHF mobiles are also portables, have four VHF portables
(3) 1970 figure
(4) Sworn officers

Table 26 indicates a clear cost advantage for Alternative B (a single dispatch center for all ten cities), but other considerations may well indicate the establishment of two or more centers The general conclusions that might be drawn from this comparison are

- For a 5-yr period, there is little or no cost reduction resulting from the combined automated system (although the life of such a system would probably be much longer than 5 yr, assuming a 15-yr period, the cost advantage is clearly in favor of Alternative B or C. Consequently, the improved service provided to the public must be heavily weighted in evaluating such systems However, inflation of personnel costs could result in a clear cost advantage even over a short period.

- Changing to an automated system is costly (note the sharp increase for Alternative A over existing systems), but the costs can be significantly reduced by changing at the same time to a combined multijurisdictional system.

- All automated systems reduce significantly the proportion of total costs devoted to personnel costs.

Some of the major advantages of having a consolidated, multicommunity computer-aided system in place of multiple manual systems were mentioned at the beginning of this chapter There are a number of additional benefits of implementing such a system, some of them related primarily to the automation of the command and control functions and some to their consolidation. These are briefly summarized below.

Improved Dispatching With promptly updated status always immediately visible, instant access to all required files in the computer, and automatic input of all routine data (time, data, ID's, etc) by the computer, the dispatcher can process dispatches faster and more accurately

Use of Resources With the status of all forces of the cooperating communities on view at a central location, these forces can be allocated in a more efficient manner and can be mobilized to handle crossjurisdictional incidents more effectively.

Table 25 Cost of Alternative B (dollars)

	CAPITAL OUTLAY	
a.	Renovate Dispatch Facility	50,000
b	Radio Consoles	29,000
c	Telephone Consoles	12,000
d	Logging Tape Recorders	33,360
e.	Instant Playback Recorders	17,100
f.	Microfiche Display Units	32,000
g.	Conveyor Belt	20,000
h	Modify mobile and portable radios	60,000
i	New mobile and portable radios	109,000
j	Monitor receivers	500
k.	New base stations	110,000
l.	Install radio control circuits	200
m.	Install emergency telephone lines	2,735
n	Install business telephone lines	–
o	Install Automatic Call Distributor	2,000
p.	Install Key Telephone System	1,500
q.	Install Hot Lines	180
r.	Data Management System	817,000
s.	CRT Terminals	54,600
t.	Modems	–
u.	Install data lines	–
v.	System Design, Specs, and Management	300,000
	TOTAL CAPITAL OUTLAY	$1,651,175
	OPERATING COSTS (ANNUAL)	
a	Radio Control Circuits	874
b	Emergency telephone lines	1,512
c.	Automatic Call Distributor	14,400
d	Key Telephone System	9,600
e.	Hot lines	5,787
f.	Data Lines	–
g.	Salaries, Dispatchers	760,000
h.	Salaries, Supervisors	90,000
i.	Overhead, at 60% of salaries	510,000
j	Maintenance	124,000
k.	Supplies	6,000
	TOTAL OPERATING COSTS	$1,522,173

CAPITAL OUTLAY PLUS OPERATING COSTS	$3,173,348

Table 26. Comparative Costs of Alternatives, 1975-1979 (thousands of dollars)

	Existing Systems	Alternative Systems		
		A	B	C
Capital Outlay	202	1,874	1,651	1,795
Operating Costs	10,745	14,740	7,620	10,285
Total	10,947	16,614	9,271	12,080
Annual personnel costs as a percentage of total annual costs	0 92	0.78	0 72	0 74

Response to Calls With an Automatic Call Distribution System to allocate incoming calls to the next available operator, calls can be served in the sequence of their arrival and answered more rapidly because the CBO resources have been pooled

Call Processing. Taking of incident data by the CBO is made faster and easier by the keyboard/CRT procedure. Routine data is handled by the computer, and information given is checked for validity (especially addresses). With the ANI/ALI feature of the 911 system implemented, location and telephone number can be entered automatically. The address verification function of the computer will also automatically indicate which police department has jurisdiction over the location of the incident.

Reduced Response Time. Because of the faster operation at both the CBO and dispatcher positions, and the more accurate information available to both, overall response time may be reduced.

Physical Security. With one or two locations rather than five to ten, it is easier to assure the physical security of the dispatching operations.

Dispatcher Efficiency. The efficiency of the dispatcher is not only improved by the automated functions, but by a quieter working environment and reduced stress during peak load periods. Other features that help improve dispatcher efficiency and reduce stress are the instant-playback recorders (permitting recovery of information that was not clearly understood and cannot be repeated).

Officer Safety. The safety of field is enhanced by several features of the automated system. information on suspicious vehicles and persons is provided to field officers in seconds, automated timing by the computer indicates when a unit is overdue to report; access to radio channels by field units is less subject to delay, digital communications are less subject to being overheard, field units can contact directly other field units, including those of other departments in the combined system.

Reduced Clerical Load. The computerized command and control system not only reduces drastically the clerical tasks required of CBO and dispatcher, but can eliminate or replace much of the clerical work required of field officers in filing reports and will also perform most of the compilation and preparation of management reports and required statistical reports

APPENDIX A

DESCRIPTION OF OAK PARK, RIVER FOREST, FOREST PARK COOPERATIVE CAD SYSTEM

Three adjacent suburban communities in Illinois, in the vicinity of Chicago, recently installed a cooperative CAD system for use by all three police departments. The cities involved are:

- Oak Park, population 62,500.
- River Forest, population 14,400.
- Forest Park, population 16,000.

The system was designed and installed by a firm in Champaign, Illinois (Community Technology, Inc.) and began daily operation in April 1974. It is known by the trade name of AIDS (Automated Interactive Dispatch System).

Figure A-1 shows the configuration of the system in a simplified form. Note that it interfaces with the Illinois automated law enforcement data base (LEADS, Law Enforcement Agencies Data System) and with the NCIC, through the AIDS computer.

Figure A-2 is a more detailed block diagram of the Oak Park dispatch center, where the CAD computer is located, showing also the interfaces with the River Forest and Forest Park dispatch centers. Note that each of the departments has two dispatch positions with display and keyboard. Only the Oak Park department has a separate complaint operator and a special display position for the chief, enabling him to view any of the other active console displays.

As Figure A-2 indicates, the heart of the system is a Data General Nova minicomputer with 24K words of core storage plus its loader, restart device, and clock. The disk storage is a unit with a capacity of 28 million characters. Magnetic and paper tape drives are included in the system, along with a printer for general-purpose output from the computer. This is not the printer used by the dispatchers; the diagram shows that each department has a printer associated with the dispatching consoles

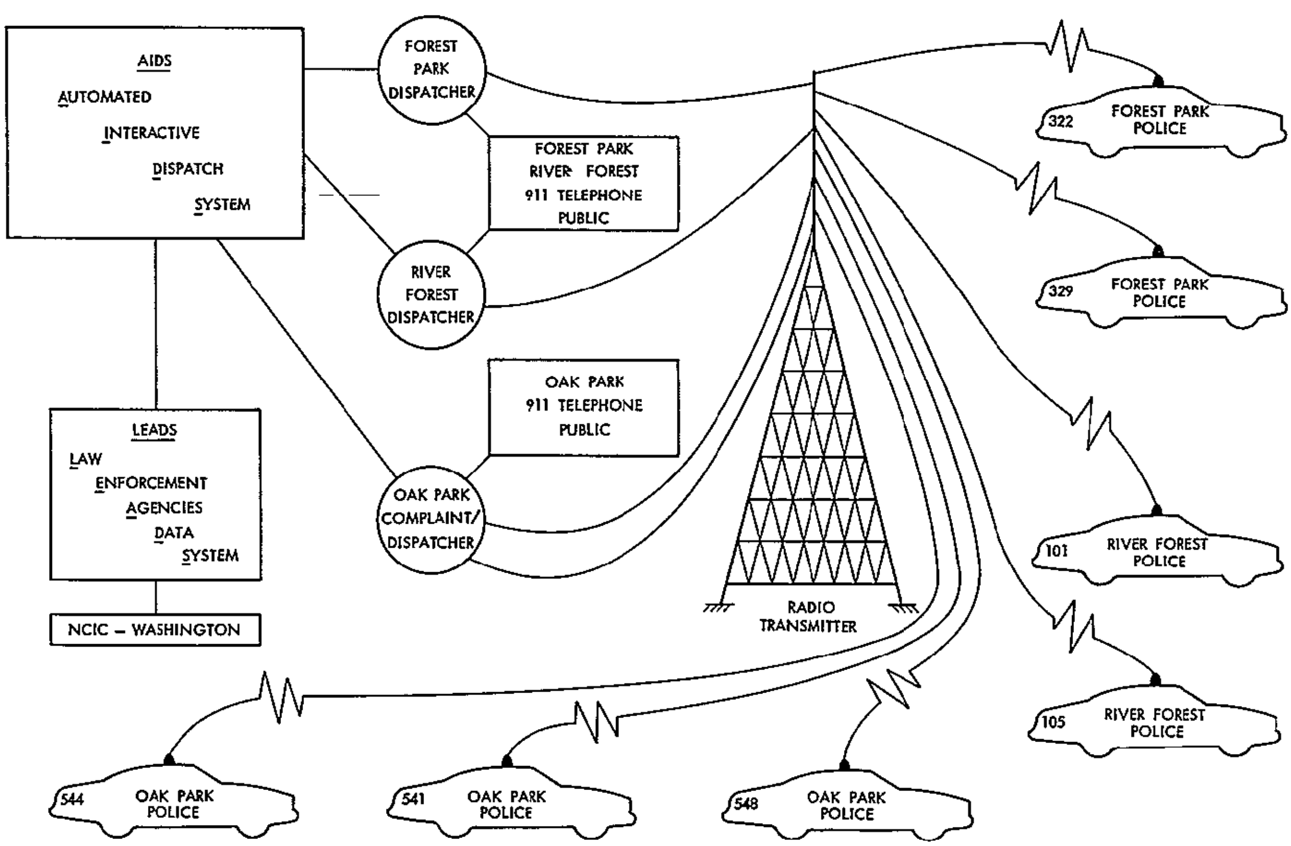

Fig. A-1. Communication system

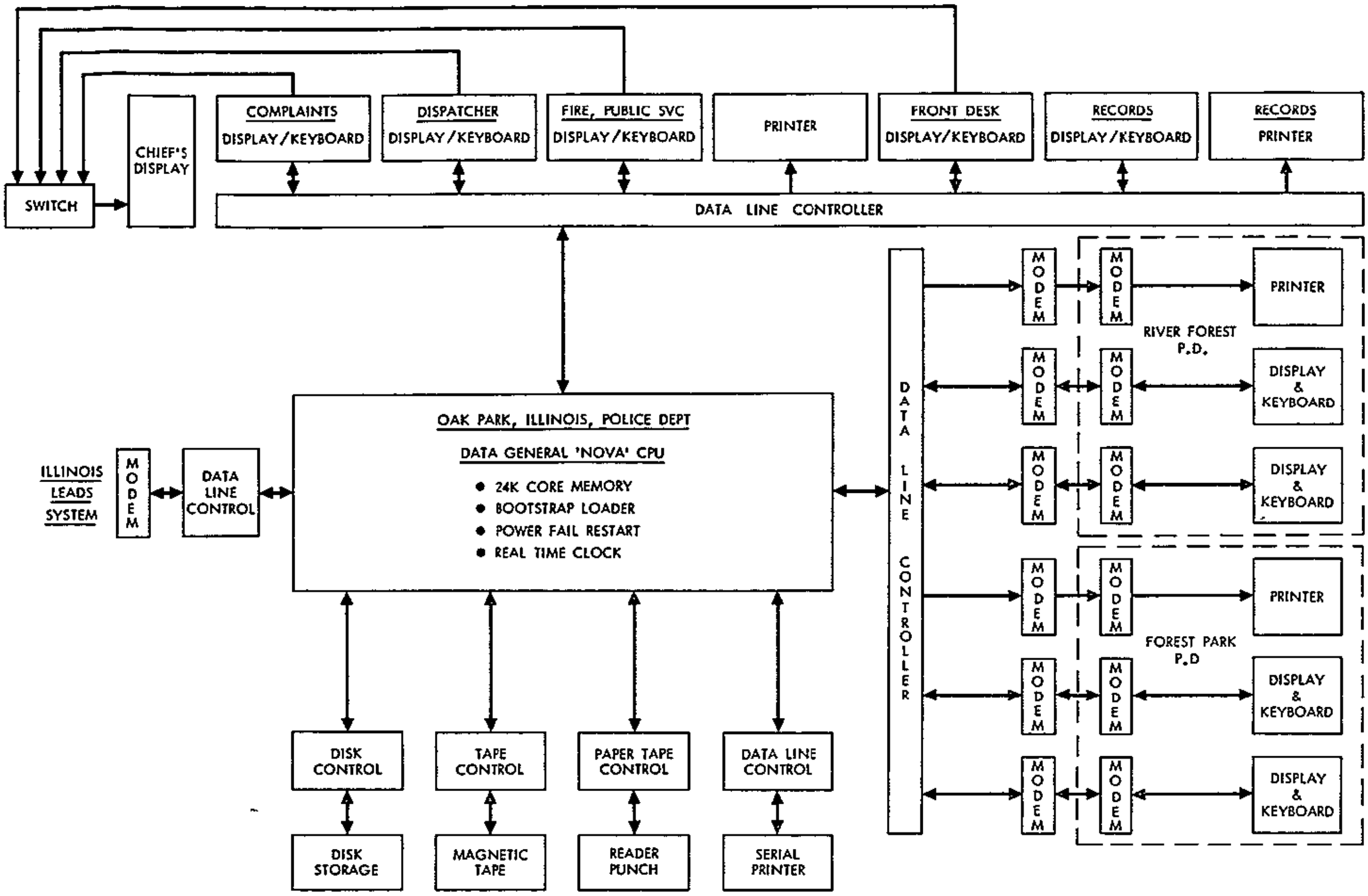

Fig. A-2. Oak Park system block diagram

The consoles have single-screen displays. Each screen is divided into four areas There are 24 lines altogether in the display (with up to 80 characters on each line), allocated as follows

Line 1 - 11	Incident record* or responses from LEADS or NCIC
Line 12	Queries to LEADS or patrol unit status update or NCIC.
Line 13 - 21	Unit status table or incident status table
Line 23 - 24	Messages from the CAD system or from other operators

*In this system an incident record is called a dispatch ticket

Figure A-3 shows the alternate forms of the display. The operator can call up either type of information to the display area reserved for it, but with one screen he cannot have on view at the same time, for example, both the incident status table and the patrol unit status table.

The keyboard is illustrated in Figure A-4. It consists of an ordinary typewriter keyboard plus special function keys shown to the left and right. The keys on the left are editing keys for positioning the input and adding or deleting single characters or entries The keys on the right are dispatch function keys with the functions listed in Table A-1.

The operation of the system is summarized in Table A-2, which lists all the entries on the incident record (with number of characters alloted to each) and shows the source of the entry in each case The important point to be noted is that the system itself automatically provides many of the entries with no intervention required by the operator or dispatcher. Serial numbers, dates, and all times are automatically entered by the

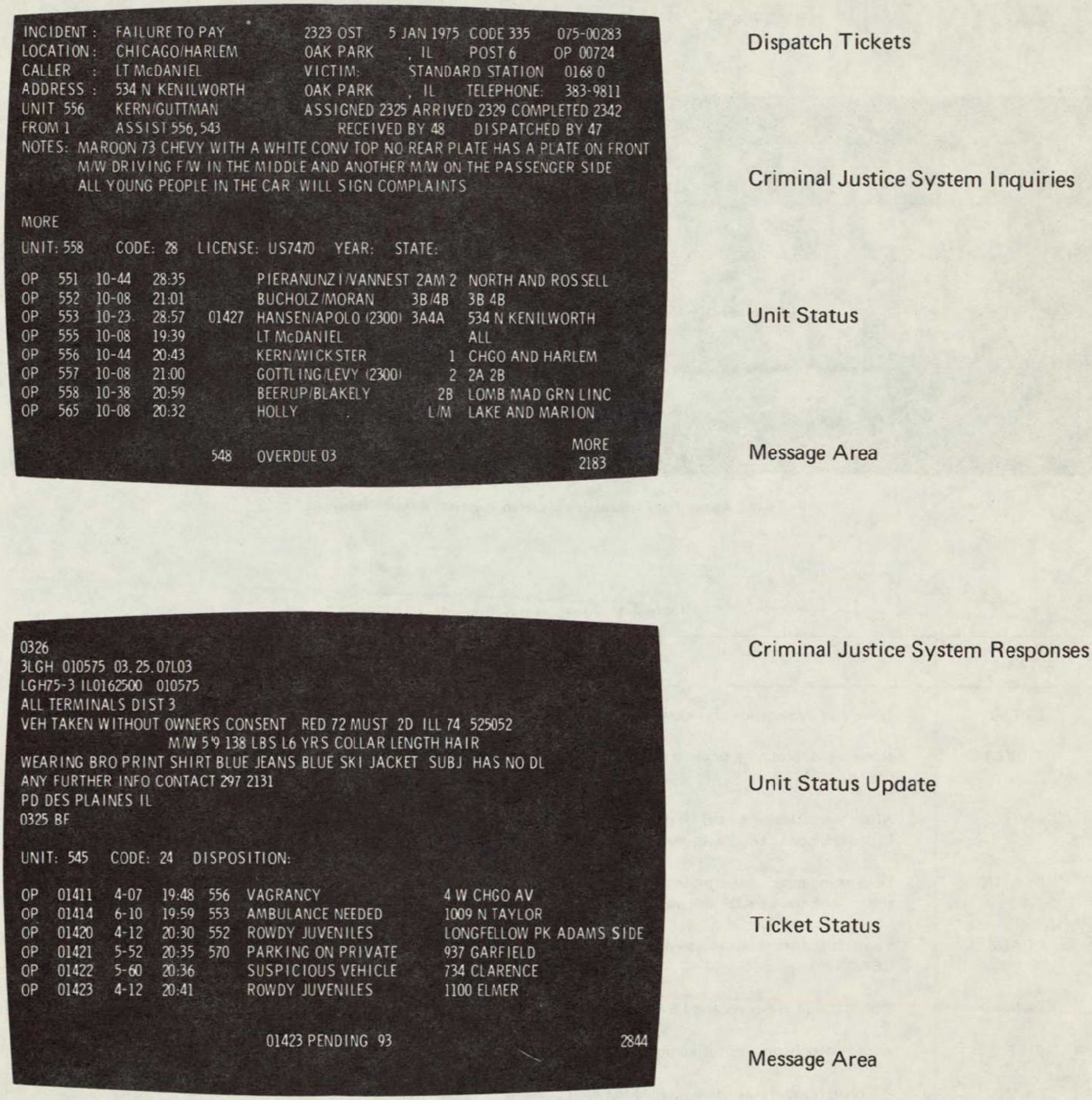

Fig. A-3. Display formats

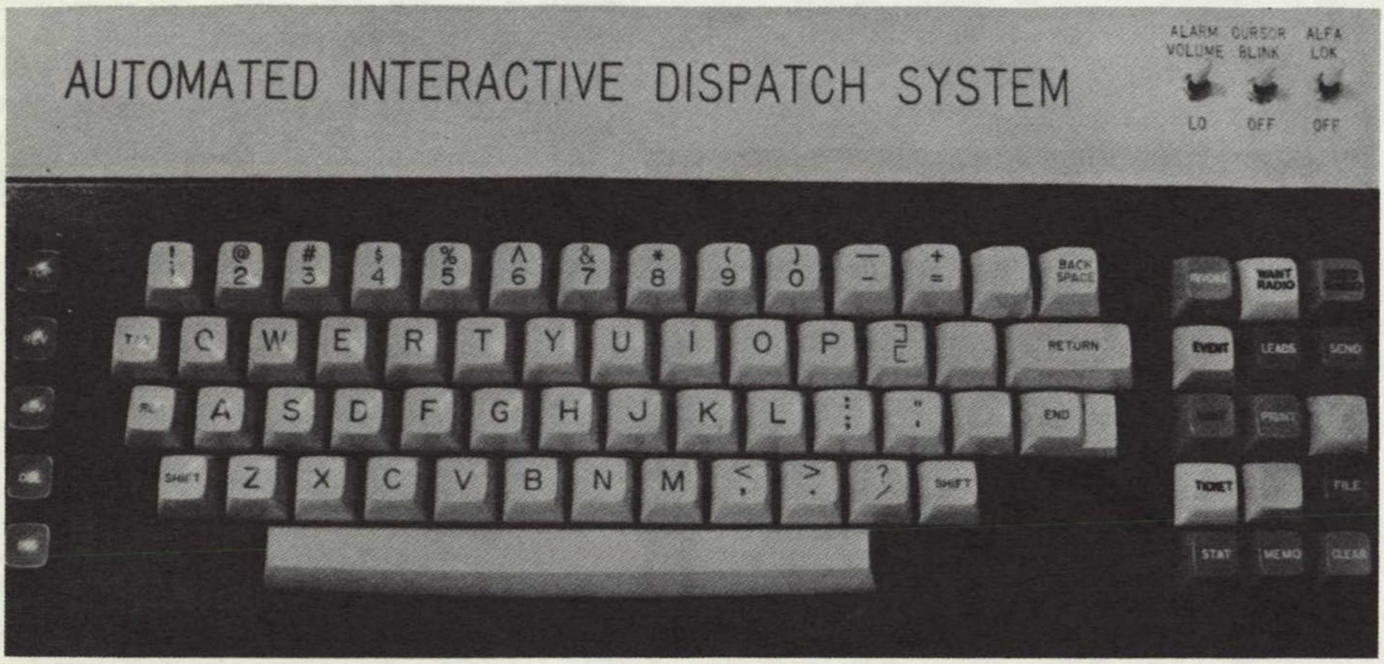

Fig. A-4. Automated interactive dispatch system: Keyboard layout

Table A-1. Function Key Operations

Key	Function
EVENT	Generates a new dispatch ticket for an incident, given a location and (optional) incident code.
TICKET	Recalls and displays a ticket given the ticket number. It is used with the STATUS key to display the ticket status file.
UNIT	Alters the status of a patrol unit, given the patrol unit number, a status code, and possibly some other data depending on the code. Used with the STATUS key to display the unit status file.
STATUS	Used as indicated above to display ticket and unit status tables. Also used with the LEADS key to display recent traffic with the LEADS system.
LEADS	Formats and transmits messages to the LEADS computer. Used with the STATUS key, as noted, to display LEADS messages.
PRINT	Causes dispatch tickets and LEADS messages to be printed out.
FILE	Assigns document control numbers to dispatch tickets.
MEMO	Performs limited message switching between consoles.
CLEAR	Clears the display screen.

Table A-2. Ticket Fields

Field	Size	Information Provided by: AID System	Complaint Operator	Dispatch Operator	Notes
1. Ticket number	5	X			
2. Control number	8	X			
3. Date	7	X			
4. Time	4	X			
5 Incident code	4		X		1
6 Incident	24	X			2
7. Location	24		X		1
8. Zone	4	X			3
9. Department	2	X			
10 Caller	24		X		
11. Victim	24		X		
12. Address	24		X		4
13. Telephone	7		X		4
14 Unit assigned	4			X	1
15 Officers	24	X			
16 Zone responding	4			X	1
17 Time assigned	4	X			
18. Time arrived	4	X			
19 Time completed	4	X			
20 Disposition	3			X	1
21. Assisting units	24			X	1
22 Received by	4	X			
23. Dispatched by	4	X			
24. Notes	216		X	X	

Notes 1 For convenience, these fields are filled by the system with information obtained from the operator expressly for this purpose

2 The information for this field is determined from the incident code, if one is supplied Otherwise, it must be entered manually by the operator

3 The information in this field is inferred from the location

4 When Automatic Number Identification (ANI) or Automatic Location Identification (ALI) capability becomes available through the telephone system, these fields may also be automatically filled

computer. On item 6, the type of incident is entered by the computer on the basis of the incident code entered by the operator. The zone is determined by the computer on the basis of the address given, and the department (city) is also entered automatically. When the dispatcher assigns a patrol unit the unit number is entered in the incident record and at the same time the unit status record is updated. The ID of the person receiving the call (complaint operator or dispatcher) is entered by the computer from its personnel roster, as are the names of the officers (or officer) in the patrol unit assigned The computer maintains the link between the incident and the unit assigned, and makes the appropriate entries automatically. Thus, when the unit reports arrival on the scene, the time of arrival is automatically entered in the incident record when the dispatcher updates the unit status file The same occurs when the incident is closed.

The console operator thus makes virtually no entries directly to the incident record once the initial basic information has been entered (whether by the complaint operator or by the dispatcher directly). By updating the status tables, he causes the required information to be entered automatically in the incident record.

Queries to remote data bases (LEADS and NCIC) are entered directly on the dispatcher's console, and the responses can be displayed there as soon as received (although they are printed out on the printer in any case). The computer automatically prepares queries in the correct format for the system being queried; this saves many unsuccessful attempts resulting from trivial format errors in the query.

The system keeps a time-ordered file of all events known to it, and all messages transmitted or received over the law enforcement information network are also recorded. This complete file is used as the source for unit activity reports and all statistical reports including the Uniform Crime Reports

APPENDIX B. ANNOTATED OUTLINE OF BY-LAWS TO JOINT POWERS AGREEMENT

PREAMBLE

Defines the new agency and its purposes

ARTICLE I

Lists the functions of the agency, which are those of any legal entity make contracts, hire employees, acquire and dispose of property, incure debts

ARTICLE II

MEMBERSHIP

Defines what agencies are eligible for membership

Defines conditions of membership

Specifies procedures for admission to membership (i.e., vote by the Board of Directors)

ARTICLE III

BOARD OF DIRECTORS

Defines membership of Board of Directors (one from each membership agency)

Provides for alternates

Defines what personnel of member agencies are eligible to be named to the Board of Directors

Provides for succession if a representative ceases to be a member

Identifies ex-officio members of the Board (i e., Executive Directors of the Agency and chairpersons of the Executive and Technical Committees)

Specifies officers of the Board (chairperson and vice chairperson) and how they are elected Executive Director is ex-officio secretary

Specifies how vacancies in officer positions occur and how they are filled

Defines duties of officers

Defines schedule for meeting of Board and procedure for notification of regular and special meetings

Defines voting procedure in the Board of Directors (no proxy or absentee voting permitted in the example)

Defines a quorum

Specifies how rules are to be made and relationship to existing statutes covering such public bodies

Prohibits payment to board members for attending meetings

ARTICLE IV

POWERS AND DUTIES OF THE BOARD

Defines Board as the governing body of the agency

Defines authority of the board (very broad) to operate the agency and manage its affairs, including accepting of contributions, donations, or grants

Provides for annual budget procedure and annual independent audit

Authorizes board to enter into separate contracts with member agencies for data processing and management information services in addition to those performed under the agreement

Provides for employee membership in any retirement system

Requires board to maintain adequate public liability insurance

Specifies procedure for establishing meeting agendas and for subjects proposed by members for consideration

ARTICLE V

EXECUTIVE COMMITTEE

Establishes an Executive Committee, defines membership (in this case, the city manager or chief administrative officer of each member agency), procedure for electing and replacing officers, meeting schedule and notification procedure, voting procedure, quorum, procedure for establishing rules

ARTICLE VI

POWERS AND DUTIES OF THE EXECUTIVE COMMITTEE

Defines function of Executive Committee as implementing the program of the agency in accordance with policy established by the Board of Directors

Executive Committee reviews and revises if appropriate the budget submitted by the Executive Director before submission to the Board of Directors. Executive Committee controls expenditures of approved budget. Committee can transfer funds within the budget and must provide regular reports to board of Directors on budget and financial transactions.

Executive Committee appoints and removes the Executive Director.

Executive Committee can appoint subcommittees for specific purposes and reviews recommendations for forwarding to the Board of Directors

ARTICLE VII

TECHNICAL COMMITTEE

Defines Technical Committee and its membership (in the example, the police chief and fire chief of each member agency)

Provides for formal designation of members and alternates and replacement when necessary

Establishes officers of Technical Committee and procedure for electing and replacing them (chairperson and vice chairperson, recording secretary is appointed)

Provides for regular and special meetings and notification thereof, and for voting in the committee (one vote per representative). At least one member from each agency required for a quorum, no proxy or absentee voting

Provides for establishment of rules and specifies that no member shall be paid for attending meetings

ARTICLE VIII

POWERS AND DUTIES OF TECHNICAL COMMITTEE

Defines function of Technical Committee as providing technical and operational expertise

Technical Committee reviews and mediates any disputes relating to any technical operation of the agency brought before it by the Executive Director, provides for appeal to Executive Committee

Defines matters requiring Executive Committee action (i.e., communications equipment modification, bid specifications for equipment)

ARTICLE IX

EXECUTIVE DIRECTOR

Defines Executive Director as chief administrative officer of the agency. Lists his powers and duties (administer agency affairs, appoint and manage employees, prepare budget, serve on Board of Directors, attend meetings of Executive and Technical Committees, etc)

ARTICLE X

FINANCES

Defines fiscal year of agency

Specifies procedure for budget preparation, submission and adoption

Provides for determination of yearly membership assessment for member agencies. Specifies percentages for each agency during Phase II operations and provides for adjustment if new agencies join

Specifies percentage assessments for Phase IV Provides general formula for operating expenditures· each member assessed a share in accordance with the weighted formula 40% system utilization, 30% population, 30% assessed valuation

Establishes categories of charges (initial Phase IV operations, expenditures benefiting all citizens of the members, expenditures for special equipment and services for one member agency, expenditures for 911 service)

Specifies that initial assessment percentages shall not change for first 5 yr of agency operations except by unanimous consent of original member agencies

Provides that any agency in default on financial obligation to the agency shall have no vote during period of default

Provides for treasurer and controller of agency and for property custodian

Provides for identification of tort liability in accordance with state law

ARTICLE XI

EQUIPMENT AND OPERATIONS

Names functions, location, and access authorization to the central dispatch operation to be set up

Prohibits public safety employees of member agencies from being used for any functions in the operations center, and specifies that no employees of the agency shall be public safety employees as defined by law

Title of all equipment remains with agency except for any equipment specifically allocated to a member agency

Provides for equipment installation and maintenance by agency technicians

Defines equipment costs for general agency purposes and those intended for equipment for use of one member agency (or any number less than all)

Provides for FCC licenses held by members to be held in the name of the agency. Local agencies continue to hold licenses as secondary users. If any member agency withdraws, the agency must provide equivalent or better RF spectrum capability held by the member before joining

Provides that the article (equipment and operations) can be amended only by unanimous consent of Board of Directors

ARTICLE XII

WITHDRAWAL BY MEMBER AGENCIES

Specifies procedures for withdrawal by member agencies. No member can withdraw until after the initial 5-yr period of membership

Withdrawing member agency forfeits all claim to any assets of the agency, but retains title to any equipment in its sole possession

ARTICLE XIII

DISSOLUTION

Provides procedures for dissolution of agency if the number of members falls to less than three

ARTICLE XIV

DISPOSITION OF ASSETS

Provides for division of agency assets in the event of dissolution in proportion to member agency contributions

ARTICLE XV

AMENDMENT

Specifies procedures for amending by-laws Must be submitted to the Executive Committee at least 90 days before Board of Directors Meeting Executive Committee may recommend action to Board of Directors. Amendments require majority vote of Board of Directors

ARTICLE XVI

EFFECTIVE DATE

Specifies that the by-laws become effective immediately on the effective date of the Joint Powers Agreement